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The Creation and Validation of an Instrument to Measure School STEM Culture

Christopher White
Clemson University, chrisamie@bellsouth.net

THE CREATION AND VALIDATION OF AN INSTRUMENT TO MEASURE SCHOOL STEM CULTURE

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Christopher White
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Accepted by:
Dr. Jeff C. Marshall, Committee Chair
Dr. Robert M. Horton
Dr. Michelle Cook
Dr. Lisa Benson

ABSTRACT

Although current research exists on school culture, there is a gap in the literature on specialized aspects of culture such as STEM Culture defined as the beliefs, values, practices, resources, and challenges in STEM fields (Science, Technology, Engineering and Mathematics) within a school. The objective of this study was to create a valid and reliable instrument, the STEM Culture Assessment Tool (STEM-CAT), that measures this cultural aspect based on a survey of stakeholder groups within the school community and use empirical data to support the use of this instrument to measure STEM Culture. Items were created and face validity was determined through a focus group and expert review before a pilot study was conducted to determine reliability of the items. Once items were determined reliable, the survey was given to eight high schools and results were correlated to the percentage of seniors who self-reported whether they intend to pursue STEM fields upon graduation. The results of this study indicate further need for research to determine how the STEM-CAT correlates to STEM culture due to some inconsistencies with the dependent variable in this study. Future research could be done correlating the results of the STEM-CAT with participation in Advanced Placement science and mathematics, SAT/ACT scores in science and mathematics or the number of students who actually pursue STEM fields rather than a prediction halfway through the 12th grade.

DEDICATION

I dedicate this work to my children, Ben and Macie Ellen, with the hopes that they will always continue to love learning and better themselves even after they become adults, and to my wife, Amie, for supporting me through this entire process.

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CHAPTER ONE: PROBLEM AND SIGNIFICANCE

Background

All schools have a unique culture composed of the beliefs, values, resources, challenges, and practices of those schools' main stakeholder groups (Denning & Dargin, 1996). While the overall culture of the school may be well defined, it may be hypothesized that a school has multiple aspects of its culture with specific applications to the arts, athletics, or any other particular areas. Could a school foster certain *cultural aspects* such as an "athletic culture" or "arts culture" that increases the likeliness of producing division one athletes or high performing artists and musicians when compared to schools with similar demographic make-ups? Can a school foster a science, technology, engineering, and mathematics education (STEM) culture as a cultural aspect that might explain a larger percentage of students who pursue STEM fields upon graduation when compared with a similar school? There could be strong implications of the study of a STEM culture for schools considering the current state of STEM fields in the US. The current workforce in STEM fields is getting older (National Math and Science Initiative, 2014), and although a need exists to be producing more STEM workers, students in STEM fields are being lost at an alarming pace (Carnevale, Smith, & Melton, 2011). This study was an effort to define the construct of STEM culture, and create and validate an instrument that will measure STEM culture with hopes that by identifying this cultural aspect within a school strides can be made in preparing students for work in STEM fields.

Current state of STEM education. Although some may think STEM education is a passing fad in education, the need to improve literacy in STEM is an issue that needs to be addressed by the educational system throughout the nation. STEM has become a popular word in educational arenas and policy that is often used in self-serving ways or to push political agendas. Educators who reference STEM education may refer only to science, others may refer to engineering or “hands-on” learning, while politicians might reference STEM in an effort to push an agenda at the state and national level. Regardless of the focus or agenda, the government and the private sectors are spending billions of dollars to improve STEM education to fill needs within state and federal economies (Charette, 2013; Kelly 2012).

As governmental agencies continue to push STEM preparation, educators feel pressure to develop a STEM curriculum to prepare students. Curriculum development companies often sell their products to administrators who have no background in STEM. Money used to improve STEM education is often used to create non-sustainable short-term interest by engaging students with entertaining lesson plans rather than focus on the issue of improving STEM literacy (Charette, 2013).

Replacing the current workforce. The concept of a 'STEM job' is unclear as it does not have a distinct definition; some consider STEM jobs to only include science and engineering while others may include such jobs as health care workers, psychologists, or other social scientists (Charette, 2013). Evidence of a need for workers in STEM fields is often focused on science and engineering careers that can be observed in a low unemployment rate, with most having an unemployment rate below 4%, which is considered full employment (Information Technology Industry Council, 2012). Nationally, there is a growing need for qualified workers to fill STEM jobs in all fields due to the number of current workers in the field who are nearing retirement. Traditionally, workers in STEM fields tend to be white males with a large underrepresentation of women, Hispanics, and African Americans (ACT, 2014; Carnevale, 2011).

The current aging workforce in STEM fields will need to be replaced when they drop from the employed. In 2009, 87% of the Bachelor's degrees in engineering fields were held by men over age 25 (National Science and Math Initiative, 2014), and 27% of the current workforce in engineering is over the age of 50, with a median age of 41 for scientists and engineers (National Science Foundation, 2012). An aging population of workers is not unique to the fields of science and engineering because the baby boomer generation is reaching retirement age. In 2001, 80% of dentists were reported to be over the age of 45, 25% of reporting physicians in 2007 were over the age of 60, and nearly half of all registered nurses will reach retirement age by the year 2020 (Harrington & Heidcamp, 2013). The U.S. Bureau of Labor and Statistics (2015) reported the average age of several professions in the US to be approximately 42-44 years of age.

Nationally, colleges and universities need to produce students to serve as qualified workers to fill these employment needs in the coming years. Why such a focus on STEM fields when all fields seem to need qualified workers to fill gaps left by the baby boomers? As the economy advanced into a more technological age, the number of STEM jobs increased three times faster than non-STEM jobs between 2000 and 2010 (Langdon et al, 2011); this requires that vacated positions can be adequately filled as well as newly created positions.

Producing STEM students. The Apollo Research Institute asserted the increase of computerized automation will lead to a need for workers with higher-level thinking skills, computational thinking skills including statistical analysis and problem solving, and human insight to solve problems (Davis, Fidler, & Gorbis, 2011). To be successful in these STEM fields, students need to develop higher-level thinking skills through the application of science and mathematics curricula (Charette, 2013). Mathematical skills are at the forefront of this need because of the correlation between a student's mathematical and problem solving abilities. *U.S. News* contended students must master algebra by their freshman year of high school to be competitive in the job market (in Kelly, 2012). This creates concern because of a report that less than one-third of US 4^{th} and 8^{th} grade students were proficient in mathematics in 2007 (National Academies, 2007), which could imply that these same students will not be prepared to learn higher-level mathematics when they get to high school. To produce students who are capable of filling STEM jobs, educators need to encourage higher-level thinking skills by placing focus on existing science and mathematics courses and developing programs to address a currently sparse curriculum in engineering and technology.

The leaky pipeline. While there is an increased need to produce graduates in STEM fields, the number of graduates is not concomitantly increasing. The US is losing potential STEM workers between high school graduation and college when they fail to enroll in appropriate STEM classes (Metcalf, 2010; Strawn & Livelybrooks, 2012). Although students in high school are exposed to coursework in STEM, if the school does not foster a culture that values STEM, students can become disinterested. There is currently a low level of student interest in STEM careers in the US when compared to rising interest in arts, literature, and business (Rogers, 2009). Currently 32% of U.S. undergraduate degrees are in science and engineering as compared to 59% in China and 66% in Japan (National Academies, 2007; National Science and Mathematics Initiative, 2014). Studies identifying this difference in degree percentages between nations in STEM fields seem to focus on science and engineering, while placing mathematics and technology in a smaller role. These studies rarely cite statistics on the number of mathematics or technology majors, or create a small category lumping "mathematics, computers and statistics" as one field (Siebens & Ryan, 2012), and in fact these statistics are hard to come by. The evidence that differing groups often neglect some fields within STEM and focus on one field or another supports the idea that as a country we need to determine what our collective definition for STEM education is.

Entering a college major in STEM does not imply completion of these programs (Kelly, 2012). In fact, 38% of students who enter a STEM major do not graduate from those programs (Carnevale, Smith, & Melton, 2011). Students report dropping these majors because of coursework difficulty, a lack of necessary skills, or a lack of understanding about the major they entered. Many students entering these programs are not prepared to enter the rigorous coursework (Kelly, 2012). Community colleges report students often need remediation upon entering STEM programs (Kelly, 2012).

It is common that students enter STEM fields, particularly engineering, with no background understanding of what an engineer does. Twenty-four percent of high school students surveyed stated that they had little knowledge of STEM careers (Kirschner, 2011). Students also may tend to avoid STEM fields because of the difficulty of the coursework. Researchers and support groups are, however, working to support STEM majors as they matriculate through their programs (Holland, Major, & Orvis, 2012; Hossain & Robinson, 2012; Schneider, Judy, & Mazuka, 2012), but students who favor an easier path to a college degree generally avoid the STEM route.

Fixing the leak. To prepare a student to be successful in a STEM major the student should be exposed to several different science and mathematical experiences during high school. An increase in enrollment in higher-level science and mathematics courses could increase the preparation for students to enter STEM fields, which requires stronger preparation for students and a culture that supports mathematics and science education. In 2009, 96% of graduating high school seniors had taken a course in biology, 70% had taken chemistry, and only 36% had taken a physics course (NCES, 2014). These same data show only 16% of students have taken a calculus course, and 11% have taken a statistics course. To prepare students for higher-level thinking and problem solving skills, an increase in enrollment in higher-level courses is needed to better prepare them for the workforce needs of the U.S. economy. A review of program requirements for several STEM fields showed most students needed to take courses in biology, chemistry, *and* physics in addition to taking a calculus or other advanced mathematics courses. One might infer that the barriers to physics or calculus enrollment in high school are much the same as the barriers to STEM majors at the university level as students often cite difficulty of the coursework and lack of prior skills as reasons for not taking these courses. However in a smaller scale environment such as a high school, a school's culture can help navigate around these barriers because students are immersed within that culture.

Benefits of STEM Education. A case can be made that the US needs to boost STEM Education for economic benefits, but the benefits of strong STEM education for our students goes much further than the need to produce workers. In addition to helping prepare the future workforce, strong STEM education produces students who are able to interact with ever changing technologies, are creative through the use of technology, are able to solve problems in creative ways and are able to understand the world around them (Newcombe, 2010.) Our students are growing up in a world where the capabilities of technology change so fast that it is difficult to keep up with those changes. As our students experience these changes, they must have a background in the use of technology to help them adapt to these changes and function within society. These same technologies that are advancing so quickly allow for our students to be creative in their use of the technology for an infinite number of purposes ranging from the invention of social media sites such as Twitter, Facebook and Instagram to the use of technology within the art and music worlds. As our students become innovators through technology, the world around us changes at blinding speeds. Regardless of the profession these students will choose, students will be required to be problem solvers in order to be successful and move forward in their career paths. STEM education gives students the opportunities to solve problems within a safe environment in order to be able to apply those skills later in life. Finally, students must be able to understand the world around them in order to be well versed in policy issues at a local or national level. Although the framework of this study is based on the need to produce more STEM workers, the benefits of strong STEM education far exceed just the need for economic production.

Framing School STEM Culture

Student reasons for signing up for higher-level science and mathematics courses become a topic of interest if a connection exists between student enrollment in these courses and pursuance of STEM fields. If the national average of students enrolling in physics courses prior to graduation is 39%, why do some schools have enrollment of over 60% while others with the same socioeconomic background fall well below 10%? Students' performance in science and mathematics can often be attributed to the educational background of their parents (Chesters, 2015; Martins & Veiga, 2010), but is there something about the community of the school that leads students as a whole to lean towards or away from enrolling in higher-level STEM courses? A cultural aspect labeled *School STEM Culture* might be related to enrollment in these higher-level courses. If this construct is something that can be measured, research could be done to see if that aspect of a school's culture could be manipulated to increase higher-level enrollment that would lead to students who are better prepared for STEM careers. Denning and Dargan (1996) argued that there are five indicators of school culture: values, beliefs, practices, materials, and challenges. Can these indicators be measured to identify a School STEM Culture for a particular school, and how would this culture relate to course enrollment at the higher levels?

At the beginning of the present chapter, a question was posed about whether STEM education could be the "new fad" for people to push to make changes based on their own agendas, or to make money. The answer to that question is a difficult one. There are many people using STEM education for their own gain or to push their own agendas, but the issue of improving education in these fields is real and pressing. The US needs to increase the number of qualified STEM workers to prevent jobs from moving to other parts of the world. This will require improvements not only in the education students are getting in these fields, but in working to motivate students to enter the fields. Maria Klawe, President of Harvey Mudd College in California, concluded that Americans often encourage the young to pursue what they enjoy and what they can succeed at doing. At some point, Klawe argues that educators need to encourage people to pursue things that are challenging and where a need is high (2013). Although the idea that students should pursue fields where there is a high need is a great idea, it may not be practical in that if students are not interested in the field they pursue, those students will not perform their best within these fields and could become less likely to be successful. Educators need to provide relevance and motivation to students to enter these fields even though initial interest may not be immediate or intense. The teacher's job becomes to sell their content to the students who have an aptitude for the subject area. By combining exciting materials that provoke student interest, educators could push forward to change the culture of schools to increase motivation for students to pursue STEM fields and increase preparation of students to be successful in those fields.

Purpose of the Study

The purpose of the study was to determine if a cultural aspect exists within schools that could define the beliefs, values, practices, resources, and challenges of that school with regard to STEM education as defined by the students, parents, teachers, and school leadership. After creating and validating an instrument to measure the aspect of School STEM Culture, the results of the instrument were compared with the percentage of high school seniors self-reporting that they intended to pursue STEM fields to validate the construct. The following objectives guided the methods for this study:

1. Design and validate an instrument that measures the construct of School STEM Culture, defined as the beliefs, values, practices, resources and challenges regarding STEM as reported by the students, administrators, parents, teachers and counselors in a particular school.
2. Correlate the results from the School STEM Culture Instrument with the percentage of self-reporting seniors pursuing STEM fields to link the STEM cultural aspect of a school with pursuance of STEM fields by graduates.

Significance of the Study

Research in the area of STEM education is increasing as STEM education becomes more mainstream within the educational and community dialogue. An analysis of research studies published between January of 2007 and October of 2010 found over 60 articles published with a focus on STEM education (Brown, 2012). Although a strong base of STEM education studies has been developed, a review of the literature found no studies regarding the link between school culture and STEM education. If a link between school culture and STEM education can be supported through the aspect of a School STEM Culture, this would result in myriad possible research lines within the construct itself. If School STEM Culture is composed of the beliefs, values, resources, challenges, and practices of a school community as perceived by students, parents, teachers, and school leadership, research could be conducted to determine if manipulation of any combination of the sub-construct and the stakeholder would have a lasting effect on the School STEM Culture. For example, a researcher could use an intervention meant to change parental beliefs about STEM education, and give the School STEM Culture instrument as a pre/post test to determine the effectiveness of the intervention. Companies that sell curriculum to school districts could support the use of their specific curriculum by using the instrument resulting from the present study to show change in School STEM Culture after introduction to their curriculum. The school district could do a study to determine if the curriculum is worth the price paid for it. Once the construct of School STEM Culture has been clearly defined, and the instrument to measure that culture is validated, both could be used to further the status of STEM education in the US.

Limitations of the Study

Three major limitations existed within the present study, all related to the completion of the STEM-CAT Survey. Each stakeholder group was composed of a small sample of that stakeholder group and may not be representative of the total population although every effort was made to ensure that the sample group was taken from across the population to ensure a representative group. In addition to limitations with the sample group, a limitation of using the Positive Response Rate (PRR) for each sub-construct was that the PRR does not account for neutral responses. Therefore, a PRR of 38% does not mean that there was a negative response rate of 62% due to neutral responses. The author chose to focus on PPR that indicated a positive view of STEM education for each item. The total PPR assumed the responses of each individual were equal. Therefore, the school leadership responses account for a smaller portion of the overall totals because there were fewer school leadership responses in comparison to the other responses.

A school's culture is based on perceptions by stakeholders of what occurs at that school. The responses to the survey were the perception of the stakeholders responding to the survey. For example, parents may have had a perception of a lack of resources although they may not have spent any time in the building, and this may not have been an accurate representation of what was going on at each high school. It is possible that a change in culture might benefit more from a method of communicating *actual* practices within the school rather than trying to change practices that might be in line with strong STEM education.

Definitions

For the purpose of clarity of usage in the following discussion, terms are defined as follows:

Clarity Index (CLI). A measure of the clarity of an item as determined by expert review. The index is calculated by dividing the number of experts rating the item above a 7 on a scale of 1-9 by the total number of expert reviewers. The CLI will be a number between 0 and 1.

Content Validity Index (CVI). A measure of the content validity of an item as determined by expert review. The index is calculated by dividing the number of experts rating the item above a 7 on a scale of 1-9 by the total number of expert reviewers. The CVI will be a number between 0 and 1.

Culture. A system of shared orientations that holds a unit together and gives it a distinctive identity.

Cultural aspects. A portion of the overall culture of a community with a specific focus considering the beliefs, values, practices, challenges, and resources with regard to a particular aspect of the culture such as STEM education, arts or athletics.

Culture domains. Categories within a culture used to define that culture composed of the beliefs, values, practices, resources, and challenges of the stakeholders within that culture

Positive Response Rate (PRR). The percentage of responses for an item that seem to favor strong STEM education as defined in the theoretical framework. The PRR is calculated by dividing the number of responses favoring strong STEM education, including agree and strongly agree for positively coded items and disagree and strongly disagree for negatively coded items, divided by the total number of responses. The PRR can be calculated for individual stakeholder groups or combined groups.

Stakeholders. Groups of people who make up the culture of a school community including students, parents, teachers, and school leadership

STEM-CAT. A survey developed to measure the School STEM Culture of a school community.

STEM culture. The sub-culture of a school community with regard to STEM education.

STEM. STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy. (Tsupros, Kohler & Hallinen, 2009)

Sub-constructs. Components of each culture domain with regard to STEM education as based on the review of literature.

CHAPTER TWO: LITERATURE REVIEW

STEM Education

Definition of STEM education. The term STEM Education has become a popular word over the past decade. Its meaning depends on the person using the term. In general, STEM education refers to four disciplines including science, technology, engineering, and mathematics. At times, STEM refers to just one of the disciplines, and at other times refers to the four as a whole (Bybee, 2013). Stakeholders often employ the term using their own definition, creating situations where the term is used by different people in different ways. As Bybee determined, one can refer to Humpty Dumpty's statement in Lewis Carroll's *Through the Looking Glass*: "When I use a word, Humpty Dumpty said in a rather scornful tone, it means just what I choose it to mean neither more or less" (Bybee, 2013; Carroll, 1917). Frequently, people use a word or phrase within their own context, as is the case with STEM. Many see STEM education as just science and math leaving out the very relevant fields of technology and engineering.

STEM education should be a melding of the four fields into the educational curriculum because the current issues in science cannot be solved using only one discipline (Rogers, Pfaff, Hamilton, & Erkin, 2015). For the purpose of the present investigation, STEM Education will be defined as an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy (Tsupros, Kohler & Hallinen, 2009.) This definition will serve this study in that many schools do not use an integrated approach to STEM education; however, students are exposed to STEM principles in these schools through their coursework. With the increase in STEM schools across the country, a good model of STEM education should be considered by concerned educators.

Bybee (2013) identified a model for STEM education composed of four levels: purposes, policies, programs, and practices. Other studies have identified important aspects of good STEM education such as real world connections (Sherer, 2014), reinforcing learning experiences (Bottia, Stearns, Mickelson, Moller & Parker, 2015), mentoring opportunities and small group interactions (Huziak-Clark, Sondergeld, Staaden, Knaggs, & Bullerjahn, 2015.) Each of these aspects of strong STEM educational programs fits within the model outlined by Bybee, and therefore this model will frame our theoretical background for a strong STEM program for this investigation. Purposes are the various goals of STEM education in a particular area, including STEM literacy for all learners. Policies are concrete translations of the purpose: a written document identifying goals to be met. Programs are the curricular materials used to implement STEM into a school. Practices are the implementation of curriculum by the teachers in the classroom. These practices may or may not reflect the goals or curriculum, but are arguably the most important part of good STEM education (Bybee, 2013). The combination of these four levels should drive the STEM Education in a particular school, assuming that all the stakeholders have a similar vision. As a mental model of School STEM Culture is developed in the present study, these four ideas will help shape the ultimate construct.

Historical Review of STEM Education. In the 1950s, the launch of Sputnik invigorated a movement in the US to improve and focus on STEM education, although at the time it was referred to as only science and mathematics. Prior to the launch of Sputnik, the American education system had met changes after World War II when industry found that many of the workforce were not trained for jobs in technology and manufacturing (Wissehr, Concannon, & Barrow, 2011). After the launch of Sputnik in the late 1950s, President Kennedy began the 1960s by setting a goal for the US to put a man on the moon by the end of the decade. This led to the creation of several curriculum programs implementing STEM into the classroom including the Biological Sciences Curriculum Study (BSCS), the Engineering Concepts Curriculum Project (ECCP), the New Math Program, the Chemical Education Materials Study (CHEM Study), and the PSSC Physics program. These curricular materials were used in the classroom to promote scientific thinking and give students experiences that would motivate them to enter scientific fields. Over time, opposition grew against many of these programs from those who believed certain students were at a disadvantage, and that the programs did not result in equality of opportunity among students (Bybee, 2013; Wissehr, Concannon, & Barrow, 2011.)

As society moves forward and has become exponentially more reliant on technology over the last 20 years, the need for more qualified workers and students in STEM fields has also increased (Langdon et al., 2011). With growth has come an increase in research regarding STEM education from the elementary to post-secondary levels. An analysis of dissertations from 1999 to the present shows over 60 dissertations that were produced about STEM education since 2007, but less than five accepted prior to 2003 (Banning & Folkstead, 2012). The large increase in dissertations on STEM education mirrors the exponential growth of research on STEM education over the past 10 years. Regarding the extensive body of literature on STEM education, several threads of research can be identified that include (a) recruitment and retention of students into STEM fields, (b) the presence of underrepresented groups in STEM fields, (c) school wide programs in STEM and their effectiveness, (d) student interest in STEM fields, and (e) achievement comparisons between countries in STEM fields. Each of these research threads has its own place in furthering STEM education. One apparent gap in the research is the relationship between school culture and STEM education, with the connection of these constructs having implications that could push STEM education forward. This present study was intended to frame School STEM Culture within a school community to further research within STEM education.

Current issues in STEM Education. Although the use of the term “STEM” within schools is a relatively new norm, research in STEM disciplines has been present for a long period of time. Certain lines of research exist within the STEM fields, and apply to the framework of School STEM Culture in that they show the need for a strong STEM Culture within a school. These issues include, but are not limited to (a) recruitment and retention of students, (b) under-represented students in STEM, (c) student interest in STEM fields, (d) student attitudes about STEM fields, (e) achievement comparisons, (f) specialized STEM schools, and (g) tenets of effective STEM schools.

Recruitment and retention. The recruitment and the retention of students into STEM fields are at the forefront of STEM education research. The US has a workforce in STEM fields that is approaching retirement age, and there are not enough graduates majoring in those fields to fill the void left by these retirees (Langdon et al., 2011; National Science and Math Initiative, 2014). The leaky pipeline metaphor is often used to describe where students are falling out of the STEM track, and it often occurs between high school and college (Metcalf, 2010; Strawn & Livelybrooks, 2012). To combat the loss of students through the pipeline, implementation of many specialized STEM schools with an extensive application process has been created to recruit and retain STEM students; however, by including the best and brightest students in these schools, only a limited number of students are introduced to deeper STEM content. This might have a positive effect on the abilities of the students entering the pipeline, but might not increase the volume of students entering the pipeline.

Western countries often share the "leaky pipeline" issue where students lose interest in STEM domains sometime in their educational progression. Students in the Asian countries do not seem to lose their interest in these pursuits, and the pipeline in these countries remains strong through post-secondary education (Jacobs & Simpkins, 2005). Western students often remove themselves from the pipeline as they move to post-secondary education because they are not accepted into the culture of STEM fields upon beginning their college studies. These students often discuss science as being "fun," but when they get to the higher grades it is something they decide not to pursue (Archer et al., 2010). The negative attitude toward STEM studies seems to develop early. In a study done in 2013, 71% of students surveyed reported enjoying science, while only 17% of those same 10 and 11 year olds reported aspiring for a career in science (Archer et al., 2013).

The first major question that needs to be asked is why are students removing themselves from the pipeline during their schooling? In a comparative study done in 2006, Lyons analyzed studies from three countries to identify issues with science education and found three similarities appeared in science education globally. Students tend to find science education irrelevant and difficult, which leads them to shy away from those fields (Lyons, 2006).

Lyons first claimed that there needs to be a movement to transform STEM education from 'too difficult' and 'unconnected to the real world' into education that is interactive, relevant, and achievable. Students often perceive STEM education to be a transmissive subject, meaning teachers present a body of knowledge that must be memorized to be successful on a test. There is little interaction between the students and the material as it is presented as a large number of facts.

Lyons then found that student perceptions are that the science and mathematics content they learn is irrelevant to their lives (Archer et al., 2010). One of the most common theories regarding student motivation is that of Expectancy Theory developed by John Atkinson in 1957 (Schunk, 2011). Expectancy theory divides motivation into three contributing factors. Expectancy, for instance, is the notion that a student believes he or she can be successful at a task. Instrumentality is the students' concept of whether the task will help them achieve their goals and relevance is the importance of the task to the student. The motivation of the student will depend on a combination of these three constructs. Expectancy theory has been successful in classroom and business practice (Polczynski & Shirland, 1977; Quick, 1988). If a student finds relevance to the learning, the expectation that they can succeed should motivate the student to complete the task. Students often turn away from STEM courses because of the difficulty they have in navigating through those courses, which decreases their motivation.

Finally, Lyons found that students select activities in which they have high self-efficacy. The concept of self-efficacy is defined as the student's "perceptions related to skills, characteristics and competency" (Eccles, 2009; Potvin, Hazari, Tai, & Sadler, 2009). This is a self-concept that changes over time based on the student's experiences (Archer et al., 2013). A student's identity is generally considered to be specific to a field, giving them a "science identity" or a "math identity." If a student's self-efficacy is low, this generally relates to their identity in that area as well.

The second question to consider is what are some ways that educators have influenced students to engage in STEM education? Educators commonly focus on the goals of STEM education from two perspectives to influence students to pursue STEM fields. The first perspective is economic where there is a necessity for a student to pursue STEM fields to maintain personal economic stability by engaging in scientific and technology fields. The second perspective is where teachers approach students from a citizenship perspective, encouraging students to pursue STEM fields because those who are strong in science and mathematics will become good citizens due to a strong understanding of the world around them. In addition, teachers develop solid problem solving abilities in students along with several other life skills that can be learned through STEM activities (Andree & Hansson, 2013).

Beginning in 2009, Sweden implemented the Broad Line campaign as a method for recruiting students into STEM fields. It was designed by a marketing company who used common marketing ideas to influence students. The Broad Line campaign was a series of documentary-type videos with recognizable Swedish personalities who discussed their choices to pursue natural science programs. These documentaries focused on the positive outcomes of a natural science program including the formal qualifications that would lead to student access to a future education, a future career, and a work life. The documentaries showed that a natural science program can be associated with success, which can lead students to be successful and associated with desirable communities. The films also indicated that a natural science program allows students to develop certain competencies, and also allows them to enjoy science (Andree & Hansson, 2013).

Under-represented groups in STEM. STEM fields have traditionally had several under-represented groups through K-12 education, post-secondary education, and in the workplace. The three major groups who are under-represented in these fields are women, minority students, and students with disabilities. To fill these voids in the STEM pipeline, educators need to encourage these groups to enter STEM fields. These under-represented groups are not under-represented because of a lack of ability; rather, they seem to avoid STEM fields for other reasons whether they be self-efficacy, acceptance of peers, or ignorance of the fields themselves.

With research showing females generally having less interest in STEM fields, especially as they get older in the "hard sciences," such as physics and chemistry (American Chemical Society, 2015; Bella & Crisp, 2015; Carnevale, 2011), educators are working toward improving self-concept and self-efficacy in the subjects for females with the thought that this will increase interest in the fields. Although the gender gap appears in STEM fields (Archer et al., 2010; Archer et al., 2013) and seems to increase as students get older (Murphy, Ambusaidi & Beggs, 2006), it appears that the gender gap between students in STEM fields is narrowed when students are enrolled in specialized STEM schools (Levacic & Jenkins, 2005). Gender gap issues in STEM education have been studied and compared across different cultures and have been found to be generalizable (Murphy, Ambusaidi, & Beggs, 2006).

Although the low representation of females in STEM fields can be attributed to many factors, one factor is the image portrayed by science and mathematics fields. Many women consider science and mathematics fields unsuitable for them because they are not "girly" or "glamorous" endeavors (Archer et al., 2013). The desire for women to pursue fields that are considered to be 'female' fields has a large effect on the enrollment of women in STEM fields. According to Archer, the progression of a female student's identity continuously moves away from the STEM domain as she moves from early childhood to adolescence. STEM fields are thought of as academic and non-nurturing while non-STEM fields are thought of as practical, nurturing, and fashionable (Archer et al., 2013).

Upon looking at the current research on minorities in STEM fields, the majority of the research focuses on deficit oriented questions such as why few black males enroll in STEM, why minorities are disengaged in STEM fields, why persistence in STEM fields is low for minorities, and why GPA for minorities is often lower than their white counterparts (Harper, 2010). Harper argued that the focus of research should be on an anti-deficit framework that focuses on theories of how to get minorities to overcome these deficits (Harper, 2010) rather than focus on them. This allows researchers to make strides in improving STEM education for minorities rather than focusing on negative issues.

Several current programs aim to include minorities into the STEM fields by improving readiness for college math and science courses. These programs include the Detroit Area Pre-College Engineering Program that has a 90% placement rate of students into college (Mercer, 2002), the Michigan Summer Engineering Academy, and the Minority Introduction to Engineering and Science Program at MIT. The intention is to give minority students experiences that will expose them to scientific and engineering constructs giving them the background and confidence that will help them avoid any stereotypes that keep them from STEM fields.

Student interest in STEM fields. One of the difficult tasks educators face is motivating students to engage in some task. According to expectancy theory, students' motivation to engage in a task depends on the student's expectancy, or belief that they can be successful at the task as well as the instrumentality or belief that they will receive some benefit from completing the task. The valence or personal value the student puts on the outcome of the activity is also a deciding factor. Ainley and Ainley (2011) used data from the Programme for International Student Assessment (2006) to find that a student who has an interest in STEM fields places a larger connection between science knowledge and the value of science. Interest is one of the most important factors in recruiting and retaining students and workers in specific domains (Drechsel et al,, 2011; Schiefele, 2009), although a contrasting study, which also used data from the Programme for International Student Assessment (PISA)contradicted this finding by showing that countries with lower performing science students showed a higher interest in science as it applies to real life situations (Bybee & McCrae, 2011). Bybee & McCrae's study used the data from the PISA study to support their claims with minimal analysis and general comparisons, while Ainley & Ainley used a confirmatory factor analysis with data from the PISA study to support that interest in science predicts future participation in science fields. Ainley & Ainleyalso demonstrated that cultures with higher knowledge levels in science showed a stronger connection between value and knowledge of science.

To analyze student interest in STEM fields, Krapp and Prenzel (2011) defined the meaning of interest as an affective variable with a focus on a particular construct or object. In the case of STEM education, student interest could be focused on any of the four disciplines of STEM. It is important to note that several researchers link interest and attitude in particular constructs together, but they may not represent the same idea. For example, a student may have a negative attitude about a construct, such as physics, while maintaining an interest in that construct (Krapp & Prenzel, 2011). The formation of interest by an individual begins in the developmental period with interest in several natural phenomena, and over time as the student moves from primary to secondary schooling, the student's interest is shaped and formed by the strengths and weaknesses of the student (Krapp & Prenzel, 2011). These internal interests can be sustained for long periods of time. An external interest is often first presented in a course in school, such as chemistry, physics, or calculus, and will be short-lived. In certain conditions, the short-lived interests will grow into longer-term interests by a vision of relevance or particular teaching situations.

Interest can be measured using questionnaires or rating scales placing a student's perception of a particular subject or topic on a spectrum similar to a Likert scale. In 2006, the Programme for International Student Assessment (PISA) included items measuring student interest in science, with some inclusion of specific scientific domains. PISA specifically focused on the following categories: enjoyment of science, personal value of science, motivation to learn science, and expectations for a scientific career. Although there seem to be several other instruments designed with the intent of measuring interest in science, the PISA study is one of the largest scale international studies in this field.

Student attitudes in STEM fields. A large body of research exists regarding student attitudes towards STEM fields, although the set of conclusions from this body of research is somewhat limited (Krogh & Thomsen, 2005). Three major influences exist about a student's attitude in STEM fields. Personality variables are issues within the student such as self-efficacy or science identity that affect their attitude towards STEM fields. Classroom variables are external issues stemming from the school-wide factors such as instructional style or teacher personality. Structural variables are issues that are external to the teaching such as socioeconomic status of the family or the school culture. Each of these variables has a direct effect on a student's attitude towards STEM fields (Krogh & Thomsen, 2005). In framing a School STEM Culture, the effect of the school-wide factors such as instruction on attitudes in STEM became a point of focus in the design of the construct in the present study.

Achievement comparisons. Because the increase of these specialized STEM schools is a fairly recent trend, of 203 schools surveyed the median year of opening was 2003 (Means, Confrey, House, & Bhanot, 2008), the research on the effectiveness of these schools about achievement is sparse. One longitudinal study in North Carolina and Florida found a negative relationship between the number of students enrolled in STEM courses and performance in STEM areas (Hansen, 2014) suggesting that by increasing the quantity of students in STEM the quality of those students decreased. This same study found insignificant differences in STEM achievement for students in specialized STEM schools versus students in traditional high schools.

There are documented results showing a positive effect of these specialized schools on pursuit of college degrees in STEM fields, and also showing that students from specialized schools pursue STEM degrees at a 50% higher rate than students from traditional high schools (Successful STEM Education, 2011). This, coupled with the lower performance reported by Hansen, suggests that including a larger number of students in STEM fields increases interest in STEM, although the ability level of students may drop because of the larger sample of students.

School-wide STEM programs. Considering the national attention given to the need for more students to enter STEM fields, many educational systems have put a STEM focus on certain schools or academies. Enrollment in specialized STEM schools does seem to increase the percentage of students majoring in science fields, with 51% of STEM school graduates and 23% of traditional school graduates enrolling in science majors (Franco, Patel, & Lindsey, 2012). The purpose of these academies is to increase the number of students entering STEM fields; however, the method used to reach this goal does not seem to be consistent across the nation. One definition of a specialized STEM school is one that actively engages students by allowing the students choice and control over their educational experience (Thomas & Williams, 2010).

Some issues raised with the current education in STEM fields are the constraints put on education, incongruent programs across the country, the focus of STEM education in the schools, and the progression at which those fields are taught. In an effort to address under-representation in STEM fields, there is a recent move to create inclusive STEM high schools (ISHS) that maintain a focus of admitting under-represented groups and sharpening their STEM skills to allow all students equal access to high level opportunities in STEM (Means, Confrey, House, & Bhanot, 2013).

For students to make strides in their understanding of scientific, mathematical, engineering, and technology principles, those students must have the opportunity in the classroom to be risk takers who explore concepts in new ways. The constraints of the current system may not be set up for students to take risks. Much of the focus is on “passive acquisition of large amounts of content,” often resulting in a large-scale assessment. Standards used by many states are currently focused on disconnected topics that are not related to the human experience, and the focus on application to real life is obscure (Marshall, 2010). This should change with the upcoming *Next Generation Science Standards* and *Common Core State Standards for Mathematics*, but this will also require a change on the part of the teachers that will be difficult to manage. Some schools have experienced that once students are exposed to the ability to take risks to further themselves, these students often exceed expectations and rise to levels not even considered (Gott, 2011).

The current high school student is very different from high school students 15 years ago. With many technological options at their fingertips, students have much more available to them now. This immediate access to unlimited information has changed the qualities of "good students" in many schools.

Students are more often impatient, but can and will multi-task effectively and almost constantly. Students are often skeptical of traditional authority, but will take a superficial role in knowledge and meaning construction. This leads to students who are equipped, but not prepared to interact with the world of problem solving, engineering, and technology that so badly need their skills (Marshall, 2010).

Students participate more in superficial learning in classrooms of today where they have a small amount of understanding of many different topics, and have very little experience with deep learning. It is not uncommon for a current high school student to believe if he or she can repeat a definition of a law of nature, he or she completely understand the concept. This is often more applicable to the gifted and honors students than average students (Gott, 2011). It is the job of the educational system to push them further into concepts to make sure they can explain it completely.

The organization of how STEM fields are taught within the schools is another point that is inconsistent across the nation. Schools may or may not address the core engineering and technological principles and often lack the ability to relate mathematics to the other disciplines. Locke (2009) suggested a progression of STEM content beginning with the learning of basic mathematics in elementary school along with the core design process of engineering. In middle school, students would explore several scientific and engineering areas in hopes that the exposure will lead to an interest. In high school, students would examine the application of engineering and technology practices within the content areas to focus their interest.

Presently, there is no nationally accepted “best practice” for creating and maintaining a STEM Academy (Marshall, 2010). With many schools wanting to tackle the STEM education problem, they all create their own programs to help students reach national goals. It is common that these academies are generally focused on the gifted and talented students, with little support for students on lower levels academically (Thomas & Williams, 2010).

It has been argued that the exclusivity of many specialized STEM schools will not solve the nation’s problem (Petrinjak, 2011). Some programs may be more effective than others, and very few programs are the same. This incongruence between programs often leads to confusion and lack of communication to share practices.

The National Consortium for Specialized Schools of Mathematics, Science, and Technology was created in 1988 as a method of exchanging best practices between specialized schools for STEM (Thomas & Williams, 2010). This group now has over 100 members in 30 states and publishes a yearly journal to share good practice. Some studies have been done that compare specific programs that point out essential tenets of a quality STEM program, but this information needs to be shared on a more visible platform so schools can begin to come together on the STEM education issue. Teo (2012) contended that schools may often become Potemkin schools, which Teo named after Potemkin villages that had beautiful facades meant to impress passers-by, but on the inside were often much less interesting. It would be important for specialized STEM schools to create their programs for effectiveness, and not for the impression they provide for outsiders.

Characteristics of effective STEM schools. The presence of specialized STEM schools has been supported by many including President Obama in his State of the Union Speech in 2013 (Peters-Burton, Lynch, Behrend, & Means, 2013). Several political initiatives have indicated that increasing the number of specialized STEM schools should be a nationwide priority. These STEM schools often have many of the characteristics of most traditional high schools including curricular and extra-curricular activities. However, these specialized schools also have certain characteristics that foster strong STEM education while some characteristics are unique to specific schools.

The first characteristic found in most specialized STEM schools is the inclusion of some sort of senior project or portfolio (Petrinjak, 2011). Students are required to put together a project highlighting the learning opportunities they have engaged in throughout their time at the specialized school. This senior project can take many forms, but is generally a cumulative measure of learning outcomes created by the student and reviewed by a faculty member or a panel of reviewers. Sometimes the senior project can take place in the form of student research in a particular discipline (Petrinjak, 2011), which may also be reviewed by a panel of experts.

A second characteristic of specialized STEM schools is the use of an inquiry-based approach or a project-based curriculum (Peters-Burton, Lynch, Behrend, & Means, 2013; Teo 2012). These may not take the same form, but both approaches to learning are based on scientific principles and techniques and are thought to foster the scientific process in students. These approaches may take place in science specific courses or inter-disciplinary courses as well as mathematics and engineering curriculum. Schools use inquiry-based learning for the purpose of deepening understanding in particular content topics as well as improving scientific practice.

Many specialized schools utilize college level courses while students are still in high school through Advanced Placement or International Baccalaureate courses or through dual credit programs (Franco, 2012; Peters-Burton, Lynch, Behrend, & Means, 2013; Scott, 2009). By incorporating this college level coursework, students are exposed to rigorous curriculum that will prepare them for college work and put them ahead of their peers when they arrive at the college level. The specialized schools often allow flexible schedules for students to have the opportunity to take these courses in the college setting.

STEM schools are often integrated in the community and businesses around them to better prepare students to move into the world of STEM. Specialized STEM schools often seek the input of business and industry as well as higher educational institutions to create the curriculum for their students (Franco, 2012; Peters-Burton, Lynch, Behrend, & Means, 2013; Scott, 2009). These relationships can also take the form of mentorships for students, internship opportunities, professional development help, and projects that can occur in the community (Peters-Burton, Lynch, Behrend, & Means, 2013). Connecting with community and local businesses not only links the learning in the classroom to the real world, but also gathers support for the specialized school within the community.

Students at these specialized schools often learn a lot through the curriculum, but they also have opportunities outside the curriculum that can be just as valuable. The informal learning opportunities available to students can be essential in the development of the student. Some of these opportunities take place in the form of internships, service learning opportunities, mentoring activities, academic clubs and competitions, apprenticeships, and social networking (Peters-Burton, Lynch, Behrend, & Means, 2013). When these students experience the world of STEM outside the classroom, they get to see how the world around them uses the principles they learn about in the classroom.

STEM schools often have inclusive mission statements that incorporate the STEM goals into the school's plan (Peters-Burton, Lynch, Behrend, & Means, 2013). Mission statements of a school are important to remind teachers of their focus and their goals. By incorporating STEM goals into the school's mission statement, it makes STEM education a priority that will be followed and measured by the school's administrative team. These goals and measures become conversations to be had by teachers and administrators, which in turn improves instruction in the STEM fields. To go along with these mission statements, the schools often provide extensive professional development for the teachers in the school to meet the goals and vision of the school. This professional development is ongoing and time is dedicated throughout the school year to that training. During the training periods, teachers collaborate with teachers from other disciplines to strengthen the instruction.

Many STEM schools involve an admission process for students to follow. These processes may include admission requirements such as test scores, applications, essays, and sometimes demographic preference. Some schools follow a lottery system where students apply and are selected to attend the school by random chance. Although all STEM schools are not admission based, it is common practice. Often, the students selected to attend the schools are the gifted and talented students, making it difficult for students who traditionally struggle academically to have the opportunity to attend a school that focuses on disciplines in which they are interested (Subotnik, Tai, Rickoff, & Almarode, 2008).

The final characteristic that applies to many specialized STEM schools is the use of technology in and out of the classroom (Peters-Burton, Lynch, Behrend, & Means, 2013). Schools are often focused on using the latest technologies to integrate learning into our current technology centered world. Many schools require students to bring laptops to class, while sometimes schools offer the students laptops or iPads. Students are expected to be proficient in technology to compete in the global market, and these schools often push the use of technology for this reason.

These characteristics identify characteristics of many STEM specialized schools, but many also have unique characteristics that provide specific experiences to students. These experiences can be categorized into curricular and extra-curricular activities. Curricular experiences found mostly by Scott (2009) in a case study of ten different specialized STEM schools have been (a) interdisciplinary time-blocks where students spend a specific amount of time in a math/science course rather than separating them (Spillane et al., 2013), (b) upgrading STEM facilities to meet the technological needs to prepare students, (c) extra electives in courses such as organic chemistry, environmental engineering, and biomedical science, (d) requiring students to take the SAT II after completing specific courses, (e) focus on scientific literature in English courses, and (f) creating individual graduation plans. Extra-curricular activities identified by Scott include (a) community problem solving activities, (b) using real work products such as presentations or reports. and (c) requiring incoming freshmen to learn to fly a plane using a flight simulator.

School Culture

Historical review of school culture. Early research on organizational culture was first done by Rensis Likert when he analyzed the relationship between pilot, co-pilot, and bomber in World War II combat, which led to his work in organizational theory (Schein, 2004). Research on culture and climate quickly moved into the business world to improve the employee-employer relationship to profit in the business. More recently, climate and culture studies have moved into the world of education to analyze the attitude of students and teachers with regard to the climate of the school. Over time, the construct of climate and culture has grown to involve a much larger social group, beginning with a group of 3-5 military airmen, moving to a larger group in business, and now to a much broader group. School culture does not just involve the administrators and teachers; it involves the students, their parents, and a percentage of the community as well.

Defining school culture. In the 1990s and early 2000s, educators used the business model to define culture and analyze the relationship between administrators and teachers. Schein (2004) defined culture as "a pattern of shared basic assumptions that was learned by a group as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think and feel in relation to those problems" (p. 17). The entire definition stated by Schein focuses on *problems* encountered by the group and how the group deals with these problems. This connection between culture and problems fits with the overall purpose of the business world, which is to define problems and solve them in an effort to increase profitability. Schein defined three levels of culture. *Artifacts* are considered to be visible structures and processes within the organization, *beliefs* and *values* are considered the strategies, goals and philosophies shared by the group, and *underlying assumptions* are unconscious perceptions, thoughts and feelings. Although this structure is designed around the business model, these constructs, or domains, can be used to analyze culture within a school (Schein, 2004). Deal and Kennedy (1982) defined culture as “a set of shared beliefs and values that closely knit a community together” (p. 9?). Although this definition is vaguer, its broader use of the concept of community allows it to fit into other categories separate from purely the business world.

A school’s culture is considered to be the “way we do things around here” by the people embedded in the culture. However, the culture has some origin that is probably not known and evolves over time. Identifying a culture as “right” or “wrong” is a trap according to Schein (2004); instead, it should be analytical of the positive and negative aspects of a particular culture and how those aspects affect measurable properties of the school. The way a culture develops at a certain school is not as visible as student achievement or teacher performance which could be affected by the culture. Effective cultures positively affect student outcomes, which often lead to a more enabling culture. Culture, therefore, is an invisible and below-the-surface phenomenon. Only the outcomes of the culture are apparent (Schein, 2004). As a community changes, the culture changes with it and it is up to the school leadership to continue fostering an enabling climate.

Leadership and school culture. Leadership directly influences the culture of a school. This leadership can take different roles in the development of the culture. According to Schein, an administrator manages the school’s culture, while a true leader creates and changes the culture (Schein, 2004). As school leaders are developed over time, it is important they understand their role in the culture and climate of the school, allowing themselves to be a part of the development of an enabling structure that ensures trust in the faculty and the students. As teachers and students develop this trust, the community is enabled to allow for changes in curriculum or methods which will better prepare students for a world outside that culture. In a study in Turkish schools, schools were asked by their leaders to try out Curriculum Laboratory Studies. After the process, it was found that the leadership in the school had a large effect on the culture of the school (Schein, 2011).

Culture and social climate. The concept of social culture as an underlying construct for interaction of groups has developed over time in different arenas. Culture is an environment so ingrained in a social group that it is difficult for someone within the culture to assess the culture. Culture applies to any group with a shared history (Schein, 2004) and is often described as "the way we do things around here" (Bower, 1966). Much like the proverb pronouncing that *a fish would be the last to discover water*, culture is all around us all the time and is difficult for someone within the culture to notice.

Other definitions of culture. Many definitions of culture exist, often changing with the purpose of the research being done. Hoy and Tarter (1997) conducted significant work on culture in the past decade. They define culture as "a system of shared orientations that holds a unit together and gives it a distinctive identity" (Hoy & Tarter, 1997). One of the definitions presented by the Merriam-Webster online dictionary (2015) states that culture is "the set of shared attitudes, values, goals, and practices that characterizes an institution or organization." Other definitions may not discuss the identity of a unit or group, but rather suggest culture is what brings a group together. Lindahl (2006) contended that culture seems to be something an organization *has* rather than something the organization *is*, similar in that a person has a personality, but the is not a personality. This relates to Hoy's (2001) definition in that both seem to suggest the culture is a description of a group rather than something that brings the group together, which fits within the construct of school culture because schools do not come together because of the culture; rather, the culture stems from the group associated with the school. Only in the case of private schools, specialized STEM schools or magnet schools do people associate with a school strictly because of its culture. In most cases, students and community are associated with a school because of where they live. Hoy's definition describes an existing population rather than suggesting that people migrate to the culture.

Enabling cultures. Hoy (2001) defined the concept of culture by using a humanistic approach toward education, which assumes school is a cooperative learning community. They suggested learning is based on experiential activities within the community of learners that influence students (Hoy, 2001). To facilitate this type of learning, it is important to place the student in an enabling structure rather than a hindering structure. Enabling structures (a) present problems as opportunities for students, (b) foster trust, (c) teach the value of differences,(d) allow students to learn from mistakes, (e) facilitate problem solving, and (f) encourage innovation. Hindering structures (a) present problems as obstacles, (b) produce mistrust, (c) demand consensus,(d) punish mistakes, (e) frustrate problem solving, and (f) keep group members bound to the status quo (Hoy, 2003). For students to develop through experience, they must be in an enabling structure or culture which will foster their ability to learn through experience.

Five domains of school culture. As the concept of culture is inclusive of schools as organizations, it incorporates a larger group of people termed stakeholders from several different areas. The stakeholders in a school's culture include students, teachers, administrators, counselors, parents, and community members. In a group this large, to define culture, indicators must be considered that are present that define the culture of the organization. At the surface, practices and artifacts of a group are often representative of their culture (Lindahl, 2006; Zhu, Devos, &Tondeur, 2014). At a deeper level, the values of a group become strong indicators of the culture (Schein, 2004; Zhue et al., 2014), as well as the core beliefs or assumptions made by the group (Connor & Lake, 1988; Lindahl, 2006;).

The present study included the following domains: beliefs, values, practices, resources, and challenges (Denning & Dargin, 1996; Denning & Dunham, 2010; OECD, 2009). The domains of values, beliefs, and practices fall within the definitions outlined above, and the domains of resources and challenges are added to the domains. Resources can be compared with the artifacts that Zhu and Lindahl associated with culture, while examining the challenges of the culture might offer a unique look at how the stakeholders perceive adverse situations within the culture. Each domain to be included is defined below.

1. Beliefs: how we comprehend and deal with the world around us (Deal & Peterson, 1999).

2. Values: A conscious expression of what we stand for (Deal & Peterson, 1999)

3. Practices: The everyday methods that are used within the school for educational purposes

4. Resources: People or materials available within the school for educational purposes

5. Challenges**:** Issues which might hinder the educational process in STEM.

Although each of these domains stand alone, when combined across a group will define the culture of that group (Denning & Dargin, 1996). Figure 2.1 shows the critical domains that contain the overall culture of an organization that was adopted for the present study.

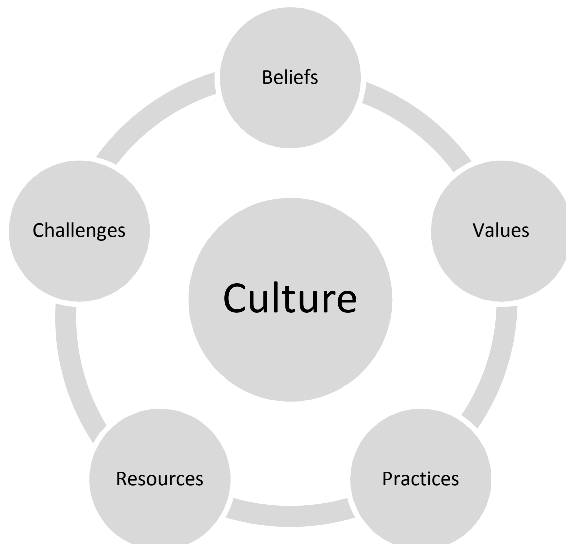

Figure 2.1. Critical domains that combine to compose a school's culture.

Research in school culture. Current research in school culture is less focused on defining the culture as a whole, and more focused on pieces of culture that, in turn, affect other aspects of the educational process. Four main lines of current research focus on school environment, faculty trust, academic optimism, and academic emphasis. Each of these lines of research focuses on faculty relationships, faculty-leadership relationships, and faculty-student relationships. These relationships can have a lasting effect, good or bad, on the educational process.

School environment. Halpin and Croft (1963) shaped a concept for organizational climate by creating a spectrum of open-to-closed climates in the school. In an open climate, teachers and principal show mutual respect for one another and are authentic in their interactions. Leadership comes easily in an open climate due to the authentic interactions between parties, which then leads to a natural state of achievement and productivity. A closed environment is classified as a situation where teachers and the principal have a superficial relationship where one may undermine the other or mutually hide true feelings. This can lead to unhealthy interactions that can hinder productivity and student achievement in the school. Hoy, Smith & Sweetland (2002) described four dimensions of school climate as identified below:

1. Institutional vulnerability: the extent to which the school is susceptible to vocal parents and citizen groups.

2. Collegial leadership: principal's behavior toward meeting social needs of the faculty and achieving school goals.

3. Professional teacher behavior: respect of colleague competence, mutual cooperation. 4. Achievement press: high but achievable academic goals. Parents, teachers and principal all exert pressure for high standards from students.

Faculty trust. To foster a culture of enablement for students, faculty trust must exist in the culture of the school. Trust in general must exist between all stakeholders in the culture for the climate of the school to be a positive one. Trust is defined by teacher behavior with regard to one another (Tschannen-Moran, 1998). Five factors that define trust between stakeholders are benevolence, reliability, competence, honesty, and openness (Hoy, 2003). Benevolence is the idea that other stakeholders will not exploit one's vulnerability. Reliability is the predictability of stakeholders. Competence is the ability to perform as expected. Honesty is the character and integrity of stakeholders. Finally, openness is the ability to not withhold from others in the community. Trust between faculty members seems to lead to greater professionalism in teachers (Tschennen-Moran, 2009). When teachers respect each other and have faith in each other as well as the principal, it fosters faculty trust (Tschannon-Moran, 1998). Faculty trust has been found to be highly correlated with a positive school climate (Hoy, 2002). There is a direct correlation between mindfulness, another construct developed by Hoy and his colleagues (Hoy, Gage, & Tarter, 2006), and trust, which leads to questions about how to develop mindfulness in teachers and a school's culture.

If mindfulness leads to trust, then the next step is moving towards collaboration within the school community. High levels of trust foster collaboration between the principal, teachers, parents, and other stakeholders. In a trusting environment, principals often include teachers in school level decision-making. Teachers will collaborate on instructional decisions, and parents will collaborate with the faculty on school level decisions (Tschannen-Moran, 2001). Trust has been directly correlated to socio-economic status, or as a negative influence, which in turn has a wide effect on student achievement accounting for approximately 2/3 the difference (Goddard, Tschannon-Moran, & Hoy, 2001) The results from this study are well controlled and robust as the authors used Hierarchical Linear Modeling, as the study was completed with one school district, however the generalizability of the results is questionable because the study was completed in all elementary schools. The concept of faculty trust could be a strong example of a culture aspect; however the data supporting this concept is focused on a small portion of the population. Although the study finds that richer schools seem to have more trust, it seems to be counterintuitive to the idea that high performing, low socio-economic schools should have very trusting relationships.

Academic optimism. Woolfolk-Hoy's research (2008) led from faculty trust to the concept of academic optimism. Academic optimism is the belief of a teacher that he or she can affect achievement by focusing on academics and learning, trusting parents and students in the process, and believing in the ability to overcome difficulties. Teachers who are academically optimistic treat their students in humanistic and trusting ways. Academic optimism has been shown to be directly related to socio-economic status with a higher socio-economic status correlating to higher academic optimism, with no correlation due to race (Hoy, Hoy, & Kurtz, 2008).

Academic emphasis. Research done by Edmonds (1979) expanded upon earlier research suggesting socioeconomic status was the main factor in student achievement. Edmonds identified five separate properties that support student achievement including strong principal leadership, high expectations for students, emphasis on basic skills, an orderly school environment and frequent evaluation of students. These five properties were later combined through analytic studies into a latent construct labeled *academic emphasis* by Hoy and colleagues (Hoy & Sabo, 1998; Hoy & Tarter, 1997). Hoy defined academic emphasis as “the extent to which the school is driven for academic excellence” (p. 79). These schools foster a positive atmosphere for students and teachers where teachers believe their students have the capability to succeed in the classroom. The school can be focused on the rest of Edmond’s properties in that teachers set high, but achievable, goals for students, and the teachers and principal pursue and respect academic success.

Academic emphasis can be found across all factors that determine school climate, including the students, faculty, principal, parents, and community members. A positive school climate will lead to increased student achievement (Goddard, Sweetland, & Hoy, 2000), which in turn can lead to better preparation and performance by students when moving to higher education. This has been found to be true through direct studies at the elementary, middle, and high school levels (Goddard et al., 2000). Using hierarchical linear modeling, Goddard argued an increase of 1 unit on the measurement of academic emphasis survey correlates to an increase of an average of 16.53 points in mathematics, with a standard error of 2.22 ($p<.001$) and 11.39 points in reading achievement, with a standard error of 1.70 ($p<.001$), at an elementary level based on state mandated tests. This highlights the importance of academic emphasis in developing a school culture that fosters student achievement.

Culture aspects. Faculty trust, academic optimism, and academic emphasis are all aspects of school community culture, which in turn affect some part of the endeavors of the school. Although these culture aspects have been researched, the present study was an effort to support that other culture aspects exist within a school community. A culture aspect was defined for the remainder of the present investigation as a portion of the overall culture of a community with a specific focus considering the beliefs, values, practices, challenges, and resources with regard to a particular aspect of the culture such as STEM education, arts, or athletics. This study focused on a culture aspect of School STEM Culture, which is the perception of the stakeholders within the community regarding their beliefs, values, challenges, practices, and resources regarding STEM fields.

Stakeholders. Although career selection for students happens over a period of up to 10 years, this decisions can be influenced by many stakeholders in the community including parents, teachers, friends, counselors, and administrators (Franco, Patel, & Lindsey, 2012). The combination of Hoy's work and Franco's work defines four major stakeholders in the overall school culture including the community, principal, teachers and students. In defining a school STEM culture, it might be beneficial to include guidance counselors, and the community group will be defined as the parents of students.

It is understood that there are other community stakeholders including industry and business; however, the parents are the most accessible community group. For the purpose of the present investigation, the four stakeholder groups that will be considered are defined below:

- Parents: any biological parent or legal guardian of a student within the school community
- Students: any student who is currently attending the school community
- Teachers: any instructor who actively instructs students within the school community
- School Leadership: any administrators or guidance counselors within the school community

There is no precedent set in the literature defining any weighting of stakeholders in comparison to each other. In the development of the culture of the school community, all groups contribute to that culture. Although there are more students within the community, the school leadership may have an equal input into the culture itself due to the large influence the school leadership has within the school community. The weight of each stakeholder's contribution to the school's culture will be addressed in future sections.

School STEM Culture

For the purposes of the present investigation, a new culture aspect of School STEM Culture is hypothesized to exist within any school community. This School STEM Culture combines the domains of school culture with the overall definition of STEM education as seen in Figure 2. School STEM Culture can be broken down into the beliefs, values, practices, resources, and challenges of the school community with regard to STEM fields.

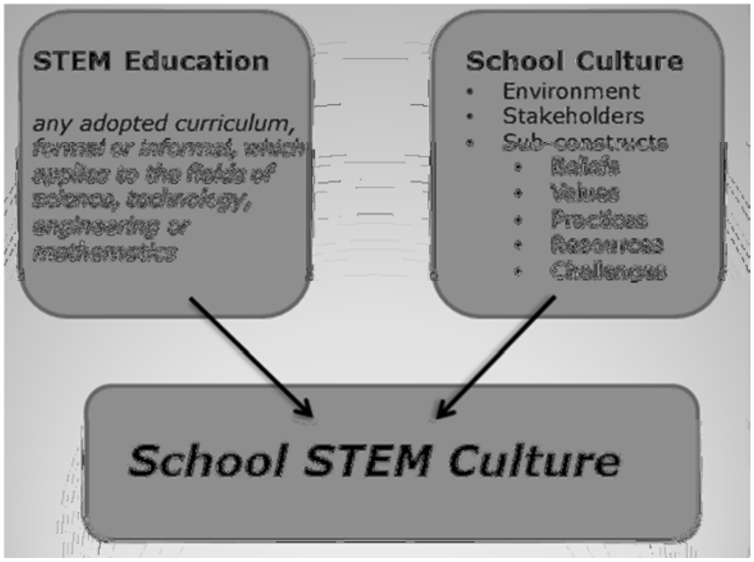

Figure 2.2. Combining STEM education and school culture to form School STEM Culture.

Construct Development for School STEM Culture

In framing the culture aspect of School STEM Culture, it is important to consider the main ideas behind school culture and strong STEM educational ideas with specific consideration to the stakeholders within the school community. School STEM Culture can be broken down into the five domains outlined within school culture research, with a specific focus on STEM education within the culture.

Domain 1: Beliefs. Deal and Peterson defined beliefs as a conscious expression of what we stand for (Deal & Peterson, 1999.) The beliefs of a group of people contribute to the culture of that group. A group of stakeholders that contribute to the culture of a school will have a set of beliefs about STEM education that will help form the school's STEM culture. These beliefs then have an effect on the practices of that school (Levitt, 2002). Beliefs about STEM education can be broken down into four sub-constructs as shown in Figure 2.3: how people learn about STEM, lesson design and implementation, characteristics of the teacher and learning environment and the nature of science curriculum (Sampson, 2013).

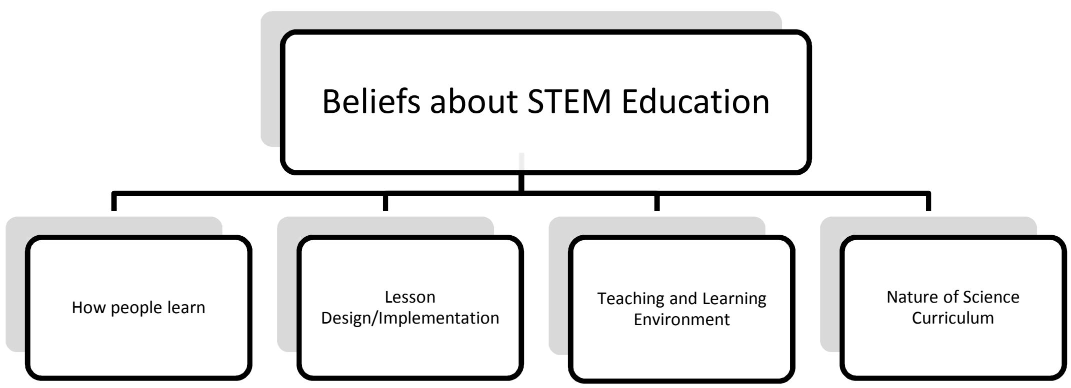

Figure 2.3. Underlying sub-constructs within the beliefs domain of School STEM Culture.

Many people have varied views of how people learn science and mathematics, often citing a traditional view and a reformed view of STEM education. People often have a framework of what STEM education should be based on one of these two frameworks (Feyzioglu, 2013; Kobolla, Graber, Coleman & Kemp, 2000; Roehri & Luft, 2004; Tsai, 2002). Traditional STEM education is often teacher-centered, with the teacher being viewed as the dispenser of information to the students. Students are viewed as blank slates upon which the teacher can add content information to build knowledge. A traditional view of the Nature of Science is a focus on scientific skills, that is, preparing students with the skills to function in society (Sampson, 2013). A reformed view of STEM education often falls in line with constructivist views of learning (Feyzioglu, 2013) with a student-centered approach that has been shown to have a positive effect on achievement when compared to teacher-centered learning (Sabah & Hammouri, 2010). Strong STEM programs often follow reformed views of STEM education and have a strong system of parent/teacher/peer support for students who struggle in STEM courses (Leaper, Farkas, & Brown, 2012). These support networks generally practice *academic optimism* (Hoy, Hoy, & Kurz, 2008) believing that each student can be successful given optimal conditions. The view of student misconceptions in this case is important as well, depending on whether the stakeholders believe student misconceptions are seen as obstacles or as building blocks (Larkin, 2012). Finally, the major factors that lead to success identify the beliefs of a group as to whether a student's ability or work ethic ultimately determines success (Upadyaya et al., 2012).

When considering lesson design and implementation, the strength of a STEM program can be evidenced by certain aspects of the lessons taught throughout the school. It is often believed when lessons are based on student interest, this can have a positive influence on student beliefs about STEM education. Other positive influences on student beliefs are the frequency with which teachers implement the engineering design process in the classroom and the regularity of which scientific and mathematical concepts are related to the real world (Nathan et al., 2010). Student opportunities to participate in STEM activities outside the classroom are also opportunities that many believe foster a strong STEM education (Simpkins, Davis-Kean, & Eccles, 2006).

Stakeholders often believe certain characteristics of the teacher and the learning environment are linked to strong STEM education. This often begins with high expectations by the teacher for student achievement, evidenced by reaching particular standards. Strong STEM programs often feature a student-centered method of learning where the teacher is viewed as a facilitator of learning rather than the dispenser of information. This provides students with an opportunity to construct their own learning, therefore creating meaning to the learning (Sampson, 2013). This type of learning is often collaborative where students learn by discussion and exchanging ideas rather than rote memorization and isolated work. It is also a common idea in reformed STEM education that good STEM education can have many different forms, and does not always have to happen in the same way, suggesting change should be the norm as opposed to consistency in the future (Yalaki, 2010).

The nature of science and mathematics in the curriculum is a topic that can be polarizing within schools. A strong STEM program often maintains a certain focus on the nature of STEM. A reformed view of the nature of science focuses on application of content understanding to problem solving and other parts of nature (Sampson, 2013). When considering STEM education, engineering education is often a topic that can be controversial in the educational system since it is not traditionally taught at each school. Many STEM schools include some aspect of engineering education at their schools, and the use of this engineering education can affect beliefs about STEM education in general. Fostering discussions on the importance of teaching the design process with teachers can have a positive influence on their beliefs about STEM education in general. Providing stakeholders with the opportunity to discuss STEM careers, to familiarize themselves with those careers, and to allow students time to discuss characteristics of people in STEM careers can influence one's beliefs (Yasar et al., 2006). It is often stated that students should learn scientific argumentation by using evidence to make claims (Crippen, 2012), and should be using reasoning during classroom discussions to provide deep discussion (Pimental & McNeil, 2013).

The Beliefs About Reformed Science Teaching and Learning (BARSTL) is an instrument developed by Sampson at Florida State University to measure student beliefs in science. The instrument has gone through validity and reliability testing in 2013 (Sampson, 2013). The items on the BARSTL focus mainly on science, although these items may be generalizable to STEM fields because many of the issues in science are similar to the issues faced in mathematics, engineering, and technology. These items provide a starting point to creating items for a School STEM Culture instrument. Using the terms adopted by the BARSTL, this study use the terms traditional and reformed STEM education, also adopting the idea that reformed STEM education are stronger in preparing students to pursue STEM fields. Table 2.1 summarizes the properties of traditional and reformed STEM education for each of the sub-constructs within the beliefs domain.

Table 2.1

Comparison of Traditional and Reformed STEM Education within the Four Beliefs Sub-Constructs

Sub-construct	Traditional STEM Education	Reformed STEM Education
Beliefs about how people learn	• Teacher controls the learning and dispenses information	• Student controls the learning • Students begin with

	• Students begin as "blank slates" • Knowledge is built from the ground up • Student misconceptions are seen as obstacles	prior knowledge of a subject • Knowledge is built from an existing schema • Student misconceptions are seen as building blocks
Beliefs about lesson design and implementation	• Lessons are based objectives as directed by the curriculum • Classroom lessons do not address real world applications • Few opportunities for learning exist outside the classroom	• Lessons are based on student interest • Classroom lessons are connected to the real world • Opportunities to learn exist outside the classroom
Beliefs about the teaching and learning environment	• Teacher is a dispenser of information • Learning is an independent process • Focus lies on finding the correct answer or using a specified order of skills	• Teacher is a facilitator of learning • Learning is a collaborative process • Focus lies of the process of getting an answer which may not always have the same order
Beliefs about the Nature of STEM Curriculum	• Focus on specific STEM skills in isolation • The engineering design process is not prevalent within the curriculum	• Focus lies on the application of STEM content for problem solving purposes • The engineering design process is used in many STEM disciplines

Domain 2: Values. A discussion of values in an educational arena can produce many definitions and contexts. Values in STEM education are sociocultural (Seah & Wong, 2012), and are defined as "the deep affective qualities which education fosters through school subject of mathematics" (Bishop, 1999, p. 2; Cai & Garber, 2012). Although Bishop's research is mostly focused on mathematics, it can be tied to most STEM fields based on his definition. Values are the traits that a group feels are important when other choices are available (Bishop, 2012). It can be noted that a stakeholder's

positive attitude regarding STEM education often reflects a high value of STEM education (Uitto et al., 2011), and that previous research has shown *academic emphasis* (Hoy & Sabo, 1998; Hoy & Tarter, 1997) in a group will foster high achievement. When analyzing the values of a particular group, one can consider three questions that define the important issues for the group.

- How important is STEM education to the stakeholders?
- What are the most important aspects of STEM education?
- Why is STEM education important?

When considering the importance a group of stakeholders places on STEM education, Bishop's Stage of Mathematics Well Being (Bishop, 2012) is an important guide. Bishop uses a scale of 0-5 to identify what level each person places the importance of mathematics.

1. Awareness of mathematics: The learner has little concept of the connections in mathematics, but relegates mathematics to a collection of activities.

2. Recognition and acceptance of mathematics: The learner identifies mathematics as a coherent activity, similar to a language.

3. Positive response to mathematics: The learner welcomes and finds pleasure in the process of using mathematics.

4. Value of mathematics: The learner appreciates mathematics in a way that leads them to seek out mathematical activities.

5. Integrated and conscious value of mathematics: The learner's appreciation for mathematics leads them to consider the use of mathematics in their future.

6. Independent competence and confidence in mathematics: The learner is an independent actor on the mathematical stage, able to make mathematical arguments.

Each of these levels of value for mathematics can be extended to meet STEM fields, and therefore, STEM in general. Stakeholders will place STEM in general at some level of importance based on their recognition and competency that will define their value of STEM.

Stakeholders in the school community might have different areas of importance they place STEM education including four major areas. Stakeholders may feel productivity is the most important aspect of STEM education, with the focus of the educational process on the production of items by the students when learning. Another focus of importance might be on authority, which is maintaining power by the teacher to ensure the teacher's concept of the content is sustained. One focal point of the STEM education may be socialization, which is the concept that it is important to educate students to maintain social norms within their community. Finally, some stakeholders believe the importance should be placed on gender differences that identify the biological differences between the genders (Dede, 2013).

Stakeholders may consider the importance of STEM education, specifically the nature of science and engineering, as applied to societal needs. There are five main areas that can be considered as important uses of STEM education. The first area is basic science/math learning, which is learning for the accumulation of knowledge. There may be little intention to apply the knowledge, but STEM learning is encouraged for the sake of knowing. The second area is democratic, which is learning STEM concepts to enable students to have educated conversations about STEM topics in regard to policy and government. The third area is cultural, which is the use of science and mathematics as a tool for culture, for example, the use of science for agricultural purposes. The fourth area is moral, which is using STEM learning to make educated decisions on moral and ethical issues in current events and in scientific research. Lastly is the utilitarian use of STEM learning, which is using STEM learning to develop technologies for the future (Wan, Wong, & Young, 2011).

Instruments regarding values in STEM fields are scarce. However, there are several existing instruments that measure student attitudes in science. A review of these instruments cites Gardner's definition for *attitudes towards science* as "the emotional reaction of students towards science…interest, satisfaction and enjoyment" (as cited in Blalock et al., 2008, p. 964). This compares closely to the accepted definition of values as what people determine to be important. A person should have a strong reaction to a field that he finds important. Blalock found the Attitude Toward Science in School Assessment designed by P. J. Germann to be the highest quality instrument to measure student attitudes toward science (Blalock et al., 2008). This instrument was used in the present study as a starting point to create items for a School STEM Culture survey.

In comparison to the beliefs domain that has a clear set of expectations that meet traditional or reformed STEM education, the values domain is not as clear as to which responses favor strong STEM education and which responses do not. Items were written in the present study by placing a certain level of importance on each attitude regarding STEM education, and therefore, positive responses were seen as responses that have a level 4 (important) or level 5 (very important) response.

Domain 3: Practices. Practices in STEM classrooms are the one aspect of school STEM culture that is the closest to the students, and therefore, is the most powerful factor linked to student achievement (Windschitl et al., 2012). Teaching practice can be categorized into instructional events and assessment events (Koedinger, Corbett, & Perfetti, 2012); however, all types of practice were considered when developing a school

STEM culture. It is often discussed that education should be grounded in “best practices,” but the question arises which practices are “best practices.” Windschitl (2012) defined four core practices identified as strong practice in science education that could be generalized to STEM education. These practices, noted in Figure 2.4, are developing big ideas and three aspects of classroom discourse including elicitation of student ideas, helping students make sense out of material activities, and pressing students for evidence based explanations (Windschitl, 2012).

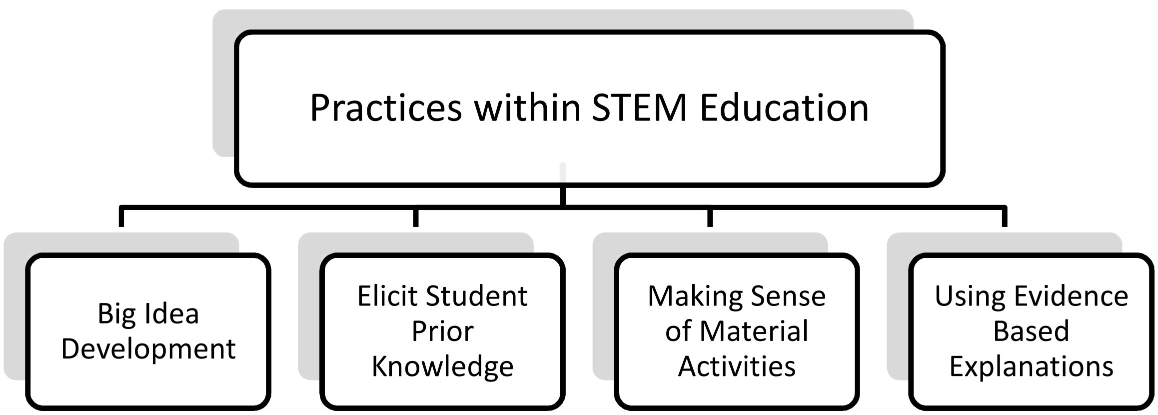

Figure 2.4. Underlying sub-constructs within the practices domain of School STEM Culture.

Developing big ideas in STEM instruction encompasses the planning stages of teaching practice. Teachers must develop an overall plan for the large concepts, guide instruction and learning over a period of time. This can be done using many strategies, including inquiry based learning. Inquiry learning allows the teacher to provide relevance and engagement for the student at the beginning of a lesson while constantly maintaining the “essential question” that holds the learning together. Providing a relevant theme of learning can bring context to the student to connect the learning to his or her world (ASHE, 2011). Although there are several models of inquiry learning (Marshall, Horton, & Smart, 2009), each one has some aspect of engaging the students and maintaining focus on a central idea.

Students often come into the classroom with their own preconceptions about ideas that are presented. Strong practice encourages the elicitation of those ideas to provide a building block upon which new knowledge can be constructed. This can happen at either the beginning of a lesson, as often happens in inquiry learning through the engagement process (Marshall, 2013; Marshall, Horton, & Smart, 2009; Miranda & Hermann, 2012; Thompson, 2009), or throughout the lesson by providing students an opportunity for self-assessment (Oliveira et al., 2013). The practice of differentiating instruction often takes place because of some initial assessment that provides the teacher with knowledge of prior conceptions of the student, which allows for strong practice (Oliveira et al., 2013).

An additional practice that strengthens STEM teaching in general is the ability of a teacher to help students make sense out of material activities. It is often considered that hands-on learning demonstrates strong practice, but this might not always be the case. Students can do activity after activity, but if no meaning is attached to the activities, then the learning is lost. This requires teachers to offer students manipulations of some sort (Thompson, 2009), and then to review the use of those manipulations to determine what the student should learn from that process. In mathematics, it is often the practice for students to complete several problems for homework each night, but if there is no connection of the problems to the content this is a futile activity (Fiori, 2007). Teachers should always take opportunities to provide feedback to students when material activities are completed (Ruiz-Primo & Li, 2013) for students to have an understanding of what they do or do not know. It is also a common practice that when students are solving problems there is no connection to real life. Teachers may describe a math problem where "they" are looking for "x" in a situation. Students should have a context as to who is "they" and why would they be looking for "x?" This important contextualization of learning will lead to strong practice (Fiori, 2007).

In STEM education, argumentation can often be used to make claims. A claim is only as strong as the evidence presented to support it, so strong practice should include a teacher pressing students to support claims with evidence (Windschitl, 2012). This means teachers could de-emphasize the "correct" answer and focus more on the questions and the explanation (Fiori, 2007). One method of increasing this ability is the use of collaborative learning through group projects (ASHE, 2011; Oliviara, 2013; Thompson, 2009). When students have the opportunity to work together to solve problems they must verbalize their thoughts, which forces them to use evidence to support their claims. Not only is it important for students to work collaboratively, but it is also important for teachers to have developed a *faculty trust* (Tschannen-Moran, 1998) that enables them to effectively work together instructionally. This is also evident through use of the nature of science (Herman, Clough, & Olson, 2013), scientific research experiences (ASHE, 2011), or the engineering design process. When a student designs an experiment or a product and has to verbally defend why he or she did what they did they will be forced to use evidence to support their claims.

Teachers will often say they are not in complete control of the practice that takes place in their classrooms. There are some common external factors that have a direct effect on the practices that a teacher is able to use in the classroom. Sometimes these external factors are positive effects on practice; sometimes they are limiting factors. The amount of autonomy the teacher has is a major factor in one's practice. If the teacher has the ability to make all instructional decisions, he or she has the opportunity to use what they feel is the best practice for their particular students. It may not always be the case that the teacher has full autonomy of the instructional decisions in his or her classroom. Other limiting factors could be the state curriculum or standards, district or state funding, class size, or testing practices. A teacher's perception of student motivation could be a limiting factor, but it could also be a positive influence on his or her practice if he or she feels the students are very motivated (Robertson & Jones, 2013). Table 2.2 summarizes the properties of weak and strong STEM education for each of the sub-constructs within the practices domain.

Table 1.2

Comparison of Favorable and Non-favorable Aspects of STEM Education within the Practices Sub-constructs

Sub-construct	Non-favorable for STEM Education	Favorable for STEM Education
Big Idea Development	• Learning is disconnected and not relevant • Learning begins without an initial "hook"	• Teacher uses relevant themes for learning • Learner is engaged through the inquiry process
Eliciting Prior Knowledge	• New learning is seen as being built on a "blank slate" • Prior knowledge is not a focus of the beginning of units or lessons	• New learning is built on top of prior knowledge • Teacher uses methods of accessing prior knowledge through pre-assessment
Making Sense of Material Activities	• Little to no feedback is given regarding activities before pending assessments • Learning is often	• Timely feedback is given regarding activities • Learning is contextualized

	isolated from the real world	
Using Evidence Based Explanations	• The focus lies on the "correct" answer with little concern of how students arrived at that answer • Independent work is encouraged over collaboration • Students are rarely asked to defend a correct or an incorrect answer	• The focus lies on the process of getting the answer and less on the final answer • Students work collaboratively within STEM content • Students are often asked to verbally defend their answer

Domain 4: Resources. Resources in STEM fields become an important aspect to providing students with quality instruction. The quality of resources can often lead to higher student achievement (Savasci & Tomul, 2013; Winkel et al., 2006). Resources in STEM fields can be broken into three categories: financial resources, community resources, and material resources. Although financial resources often lead to the purchase of material resources, it can be assumed that many institutions begin a school year with materials already in house constituting the need for separate categories of financial and material resources. Research indicates quantity as well as quality of the resources is important to achievement as well as the variety of resources available (Savasci & Tomul, 2013; Winkel et al., 2006).

Financial resources available to a school have effects on two main areas important to STEM education: personnel areas, and material purchasing areas. A school with sufficient financial resources has the ability to hire the necessary number of teachers to maintain an acceptable class size. A smaller class size has a positive effect on achievement in STEM fields (Jimenez-Castellanos, 2010; Savasci & Tomul, 2013). Research also indicates that increasing teacher salary with available funds increases achievement for students (Jimenez-Castellanos, 2010). Funding to purchase material goods can fall within the classroom category or building and maintenance. If a school is funded sufficiently, it is less likely to have small physical classroom space and portable classrooms, which can have a positive effect on achievement (Jimenez-Castellanos, 2010). In the classroom, insufficient funding for lab materials or other necessary materials can lead to large lab groups that are not conducive to effective learning. A school with sufficient funding also allows the students opportunities to participate in programs that may be expensive to run such as some of the leading engineering programs throughout the US.

Community resources are another major factor that can help or hinder a school's ability to facilitate strong STEM education. Schools with a strong STEM program are encouraged to develop a relationship with community business partners to access the needs of the community when educating the students. In some communities, this is an easy process because businesses are interested in associating with schools. There are some areas where it is more difficult to access the businesses. Volunteer resources are important to the education of the students in all areas as well. Volunteers often come into schools to serve in myriad ways. In STEM fields, volunteers might participate in outside programs for students using their expertise to help students see how STEM fields fit into the real world. Finally, local opportunity resources have a lasting effect on STEM education. Areas where students have access locally to things like field trip opportunities, educational centers, museums, and natural resources that apply to the curriculum give those schools an advantage on STEM education.

Material resources can include any materials within the classrooms, departments, or the overall school that are used to educate students in STEM fields. Technological resources, although they are very popular, are not necessarily the main need in a STEM classroom. It is important that students have access to internet resources, certain software packages applicable to the curriculum, and projecting devices for students to see throughout the class. However, it is just as important that students have access to activity and laboratory materials. It is common that science and mathematics teachers may not do many labs or activities because of the lack of materials. It is also a fairly common practice for teachers to purchase their own lab materials or ask students to purchase or bring in materials. A strong STEM program often has access to materials that allow the teacher and students to focus on content and not material acquisition. Finally, students must have access to everyday materials needed such as calculators, rulers, pencils, and paper. If students cannot access these things, it hinders the learning process in any area. Table 2.3 summarizes the properties of weak and strong STEM education for each of the sub-constructs within the resources domain.

Table 2.3

Comparison of Favorable and Non-favorable Aspects of STEM Education within the Resources Sub-constructs

Sub-construct	Non-favorable for STEM Education	Favorable for STEM Education
Financial Resources	• Larger class size • Low teacher salary • Little classroom space	• Smaller class size • Higher teacher salary • Larger classroom space
Community Resources	• Little interaction with outside community involvement • Few opportunities for field trips to local informal learning sites	• Access to community volunteers within the school building • Several opportunities for field trips to local informal learning sites
Material Resources	• Technology for learning is difficult to gain access to	• Students have access to technology in the classroom to assist in

	• Teachers purchase materials for activities on their own	learning • The school has ample materials for activities within the classroom

Domain 5: Challenges. When considering the challenges for a school regarding their school STEM culture, one must consider only the school itself. There are a number of documented challenges to STEM education in general including the push to make science relevant to the students, the link between science and society (Doulik & Skoda, 2009), the appreciation of science and technology (Simmons, 2012), and the push for contextual learning in STEM education (Johnson, 2012). These may be considered national challenges in STEM education; however, the school STEM culture is defined by the challenges evident and important to the stakeholders in the community. The myriad challenges that may occur within a school might be difficult to predict, and therefore the process of dealing with whatever challenges are presented is the focus of school STEM culture.

Organizational change is a response by the culture to the challenge itself. Cultural change takes place in stages, starting with identification of the need for change (or the challenge itself), then planning for change to address the challenge, and instilling the new culture to address the change (Muscalu, 2014; Spruytte, 2014). Leadership must identify the challenge, and all stakeholders must be familiar with the challenge within that community. All stakeholders need to be involved in the plan to handle the challenges and participate in activities to address them. The next step in the process of dealing with challenges is to begin to instill change in the community through the plan developed by the stakeholders. Through reflective processes, the community eventually reaches a place where they have effectively managed the challenge (Pater & Chapman, 2015).

They then move to the final step where they maintain the challenge and monitor for new challenges.

When considering the five aspects of school culture, the concept of challenges in the culture is an overarching theme that may apply to the other four constructs of beliefs, values, practices, and resources. Within the assessment of a school STEM culture, the challenges will apply to the other constructs within the stakeholders purview. For example, one challenge might be the need for specific resources required for quality STEM educational practice. A department may need access to a computer lab to effectively implement quality collaborative learning for the students, which could lead to quality STEM education. The presence of challenges themselves is not an indicator of strong or weak STEM education, but rather the process of dealing with those challenges. For the purposes of the present investigation, a strong STEM Culture aligned with stakeholders agreeing that the institution moved through the steps of dealing with those challenges.

Relating STEM Culture to Schools

For this investigation, the hypothesis was made that School STEM Culture informs the progress of a particular school regarding common issues in STEM education including recruitment and retention, underrepresented groups in STEM, student interest, student attitudes, and student achievement. If the cultural aspect of School STEM Culture is a measurable construct, the existence of that construct should be evident through the school's progress in each of these issues. Recruitment and retention, student interest, and student attitudes can be measured by enrollment in upper level science and mathematics courses at a particular school. Engineering and technology courses were not included in this comparison because not all schools have engineering and technology courses available, so to make a fair comparison only science and mathematics courses were used. Evidence of achievement can be found by comparing science or mathematics based standardized test scores between schools. Although not all schools take comparable science standardized tests, mathematics can easily be compared by using the ACT/SAT tests. Underrepresented groups in STEM can be measured by analyzing the enrollment of minorities and females in the upper level sciences and mathematics courses to illustrate the ability of the school to maintain these students in STEM courses.

In addition to analyzing the enrollment of students in upper level science and mathematics courses, student interest, recruitment, and attitudes towards all STEM disciplines can be measured by analyzing a percentage of a group of students who intend to pursue some STEM field upon graduation. The logical choice would be high school seniors, although it would also be possible to analyze the change in the percentage of students intending to pursue STEM fields to see if the culture of the school itself was having an effect on the students.

CHAPTER THREE: METHODS

The following objectives guided the research methods presented below.

1. Design and validate an instrument which measures a construct of School STEM Culture, defined as the beliefs, values, practices, resources and challenges regarding STEM as seen by the students, administrators, parents, teachers and counselors in a particular school.

2. Correlate the results of the School STEM Culture Instrument with the percentage of self-reporting seniors pursuing STEM fields to support the validity of the construct of School STEM Culture.

Designing and Validating the STEM-CAT

The process of designing and validating the STEM-CAT (STEM Culture Assessment Tool) was a four-phase process. Phase 1 was the initial writing of the items and review of the items by a focus group to rank and categorize each. In Phase 2, items were reviewed by a panel of experts to determine face validity. Phase 3 was composed of a pilot study to determine reliability and sub-construct validity. The final instrument was then created in an online platform. Phase 4 was composed of a construct validity of the instrument, which was tested by correlating the percentage of self-reporting seniors who intended to pursue STEM fields after graduation to the results of the STEM-CAT. Figure 3.1 outlines the process from start to finish of the creation and validation of the STEM-CAT.

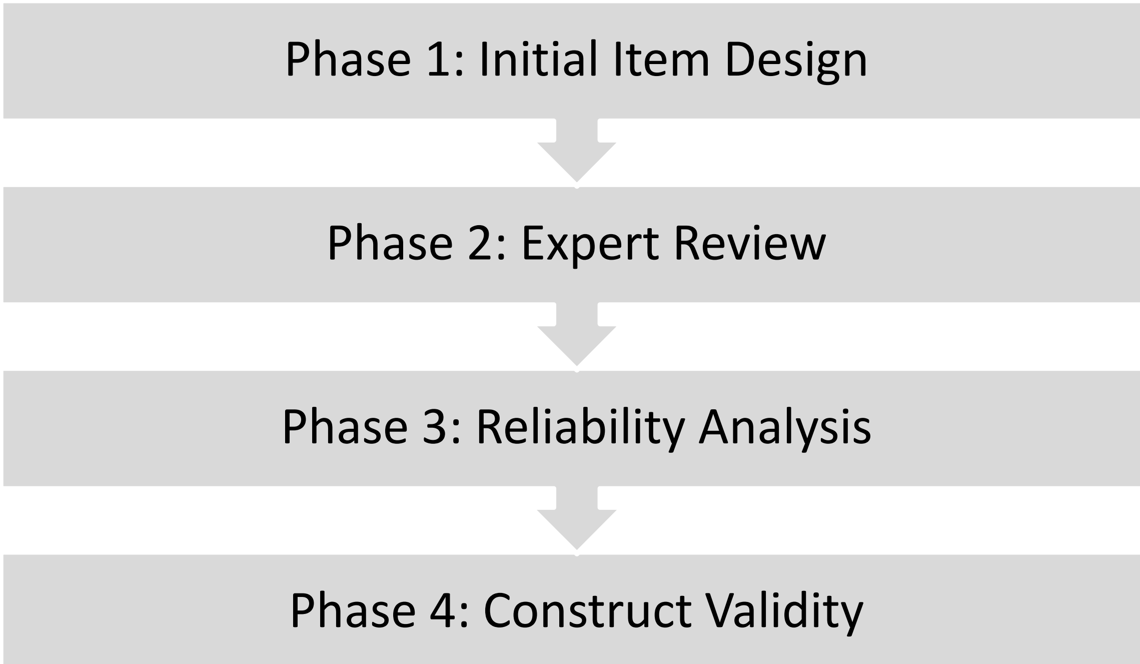

Figure 3.1 Creation and validation of an instrument to measure School STEM Culture.

Phase 1: Item development. The STEM-CAT (STEM Culture Assessment Tool) was intended to measure the STEM Culture, an aspect of culture with regard to STEM education within the community of stakeholders. School STEM Culture is defined by five domains including beliefs, values, practices, challenges, and resources as they are perceived by four categories of stakeholders within the school community. The stakeholders considered within this cultural aspect are the school leadership (including administrators and counselors), teachers of STEM and non-STEM courses, students, and parents within the school community. Items were initially developed based on the theoretical framework regarding STEM characteristics of each domain including beliefs, values, practices, resources, and challenges. The BARSTL (Sampson, 2013) is a valid existing instrument intended to measure beliefs, and was used for an initial set of beliefs items. For the other four domains, items were developed using the concepts discussed in the theoretical framework for each domain. Items were developed as Likert scale questions (Thorndike & Thorndike-Christ, 2009) with five options including strongly agree, agree, neutral, disagree, and strongly disagree. Five options were used to increase reliability of the items and to offer participants a neutral option (Thorndike & Thorndike-Christ, 2009). For most items, anchors were chosen to include strongly disagree to strongly agree for the reason that each item is identifying a characteristic of the school that may or may not exist. As shown in Figure 3.2 this question identifies a characteristic of a person's beliefs, so the responses range from strongly agree to strongly disagree.

There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.

Strongly Agree   Agree   Neutral   Disagree   Strongly Disagree

---

Figure 3.2. Sample item using Likert scale with identifiers ranging from strongly agree to strongly disagree.

Some items were created for stakeholders to identify the importance of some idea in their school or community. These items are written with anchors of not important to very important to match the purpose of the question. In Figure 3.3, the responder is indicating a level of importance of purposes for STEM education, and therefore responses range from not important to very important.

Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).

To accumulate knowledge about the world around us.

Not Important   Low Importance   Neutral   Moderately Important   Very Important

---

Figure 3.3. Sample item using Likert scale with identifiers ranging from not important to very important.

As items were written, they were identified by the author regarding the domain of School STEM Culture each item addressed, which was later used when items were being narrowed down. As items were written for each of these domains, both positive and negatively coded items were used to ensure participants did not randomly fill in responses with no consideration. Items were initially written with no consideration of the type of stakeholder that would answer the question. A full list of the initial items can be found in Appendix A.

A focus group composed of graduate students in science education (2), mathematics education (2), and educational leadership (1) met to review initial items, make changes deemed necessary, and place each item with the appropriate stakeholders. Items were classified as applying to all stakeholders, students only, adults only, school adults only, or individual groups. A short presentation summarizing each of the five culture domains was given to the focus group and the group was asked to consider the clarity and ability of each item to measure the domain at hand.

Items that were determined by the focus group to be acceptable were placed into four different item lists, one for each stakeholder, based on recommendations from the focus group. These item lists can be found in Appendix B. During the initial writing of the items, a large number of items were written to select the very best items for the instrument (Thorndike & Thorndike-Christ, 2009). Although it is suggested by some that initial items should be twice the length of the intended final survey (Hinkin, 1998), extra items were developed to ensure a large enough pool to select appropriate items.

Phase 2: Face validity through expert review. Face validity for the STEM-CAT was determined through an expert review conducted by experts in mathematics education (2), science education (2), digital media (2), engineering education (2) and instrument development (1). The experts were asked to identify the items on a scale of 1-9 in two categories: sub-construct validity within the domains, and clarity of the question. Experts were asked to use the following scale to rate each item for clarity and sub-construct validity:

9: An item that there is no doubt that it clearly and effectively measures the sub-construct at hand.

7: An item which you feel effectively measures the construct, but may leave some doubt based on wording, or understanding of the sub-construct.

5: An item which could measure the construct effectively, but the relationship between the item and the sub-construct is not completely clear to you.

3: An item which has a significant issue keeping it from measuring the sub-construct but could be improved by changing the wording.

1: An item that completely misses the main idea of the construct.

After all nine experts reviewed and rated the items, the mean, median, mode, and standard deviation were calculated for the rating of each item. Rankings with a value of seven and above were considered valid for the process, and a *Content Validity Index* and a *Clarity Index* were calculated for each item by dividing the number of valid rankings for each item by the total number of rankings (9) (Wynd, Schmidt, & Schaefer, 2003). Upon completion of the Content Validity Index (CVI) and the Clarity Index (CLI), items were removed if either of the indices were found to be below 0.75 on either index (Yaghmaie, 2003).

Once the face validity process was complete, the number of items was reduced to a minimal number of items per construct to limit the length of the questionnaire. Items were imported into an online survey instrument using Qualtrics (Qualtrics, Provo, UT), and prepared for the pilot study to determine reliability.

Phase 3: Reliability study. A pilot study was conducted in five parts, one for each stakeholder, to determine the reliability and sub-construct validity of the questionnaire. To obtain a sample size for each stakeholder large enough to determine reliability, it was necessary to recruit participants for the pilot study from more than one school. Although the instrument was intended to measure a school's STEM culture, the reliability of the items could be tested using participants from different schools in that the reliability is not measuring the construct itself, but the ability of the items to measure the intended domains. For each category of stakeholders, 50 participants were recruited to complete the survey.

Participant recruitment. Administrators were contacted through the district offices of two local school districts and asked to complete the surveys online. The surveys were completed anonymously, with no record of the administrator's personal information or IP address. Counselors were contacted through a local email list of counselors in local districts after approval by the districts, and surveys were completed anonymously, with no record of the counselor's personal information or IP address. Teachers were recruited through school-wide emails to the schools in one school district. The surveys were completed anonymously, with no record of the teacher's personal information or IP address.

High school teachers of core subjects were asked to choose their main teaching assignment from a list of options. Students from one school in a local school district were asked to complete the survey on school computers during a homeroom period. The surveys were completed anonymously, with no record of the students' personal information or IP address. Parents were contacted through a school-wide email list, and a local parent function conducted by a guidance department. The surveys were completed anonymously, with no record of the parents' personal information or IP address. No individual demographic information was asked of any of the stakeholder groups within the survey. The survey was conducted via Qualtrics, an online survey tool, and data was compiled using Microsoft Excel.

Reliability analysis. Five reliability tests were completed using items from each stakeholder group within the STEM culture for a school including the administrators, counselors, teachers, parents, and students. A sample for each stakeholder was chosen to complete a pilot study of the questionnaire. It was not imperative that the sample be a part of the same school community to determine the reliability of the items. Once the pilot studies were completed, reliability of each item was calculated using Cronbach's Alpha (Chronbach, 1951). As suggested by Cronbach in his notes on alpha (Cronbach & Shavelson, 2004), standard error of each item was calculated as well. Cronbach suggested that despite the rampant use of alpha in research, stating that his 1951 paper had been cited 5,590 times, standard error is a better determinant of reliability than alpha because it shows variability of each item. Items were removed as necessary based on Cronbach's Alpha and standard error to maintain a high level of reliability. Acceptability for alpha was set as follows for this study: below 0.7, unacceptable; between 0.7 and 0.75; minimally acceptable; between 0.75 and 0.8, acceptable; between 0.8 and 0.9, very good; above 0.9, consider shortening the scale (DeVellis, 2003).

The number of participants for each stakeholder was determined to be 50 participants. It is a commonly debated subject determining the necessary number of participants for a reliability study using Cronbach's Alpha. Common practice states that the larger a sample size using Cronbach's Alpha, the more accurate the results will be. Varying conclusions have been made in the literature stating sometimes 50 participants is acceptable, sometimes the minimum number of participants can be as large as 400 (Yurdugul, 2008). Because the reliability study was done with members of five different types of stakeholders, 50 participants from each area were chosen to include a total of 250 participants.

Sub-construct validity within domains. Once the Cronbach's alpha for many of the sub-constructs was found to be unacceptable, an exploratory factor analysis (EFA) was completed using the SPSS computer software package to determine if the items would cluster according to categories other than the categories outlines in the literature review. A Kaiser-Meyer-Olkin Measure of sampling adequacy was used to indicate that items in the survey were strongly correlated enough to conduct a factor analysis (Tabachnick & Fidell, 2001). Factors were extracted using maximum likelihood methods with oblique rotation (promax) because the factors were assumed to be related. The data presented was complete with no missing data; therefore, no reduction of data was necessary. A factor solution was obtained using Kaiser's criteria, the scree plot, the interpretability of the results, and the model fit indices indicated by SPSS, which indicated a three-factor model (Preacher & MacCallum, 2003). The EFA was used to determine the retention or removal of items from the survey being analyzed (Worthington & Whittaker, 2006). Items with a factor loading of .40 or higher were retained based on study criteria (Tabachnick & Fidell, 2001). The exploratory factor analysis was used to determine a new organizational schema for beliefs within the stakeholder groups and identified a new structure including two major sub-constructs under beliefs: beliefs about student activity in the classroom, and beliefs about curriculum and lesson design.

Final instrument development. After the five iterations of the pilot study were completed, and items were determined to be reliable, a sub-construct validity was developed, and the final version of each iteration of the questionnaire was completed. The survey was constructed using Qualtrics (Qualtrics, Provo, UT), with one survey that asked participants to identify which type of stakeholder they were, and then provided the appropriate items for each stakeholder.

Phase 4: Overall construct validity. Once the iterations of the instrument were determined to be reliable, and the sub-construct development was considered to be valid, it was necessary to determine the overall validity of the construct of School STEM Culture. Construct validity was determined by administering the School STEM Culture Questionnaire to the stakeholders in eight different school communities.

Recruitment of participating schools. Schools were originally recruited to participate in the study through email messages that were sent to principals and assistant principals in February of 2014. A message was sent to a random selection of three schools from each of the 50 United States. Schools chosen had a range of 900-2,000 students. The original recruitment email was titled "STEM Education at XXX High School" and included information about the study, along with some information about what would be asked of each school. Of the 150 schools originally recruited, 24 schools responded to the original recruitment email. Of the 24 schools that responded, 18 denied the request to complete research in their building, two schools agreed, and the other four schools gave contact information to request a research project within the district. For the four schools that gave district level contact information, after completing the research application, there was no response either at the district level or the school level. A second recruitment email was sent to many of these schools in April of 2014, with a response from 22 of the schools. All of the responses to the follow-up recruitment email indicated that it was too late in the school year, or that their students were surveyed too much. Three of the schools made the comment that they did not have a STEM program, which is why they would decline participation. Because this step was completed in April of 2014, it was decided to wait until the fall of 2014 to continue trying to recruit schools.

In the Fall of 2014, several phone calls were made to schools on the recruitment list. When calling a school, a request was made to speak to the curriculum coordinator or an assistant principal in charge of science and mathematics. After calling more than 70 schools, I spoke with either a curriculum coordinator or assistant principal at 27 schools. For six of the contacted schools, the person contacted indicated some interest in the study, but all six of the schools decided not to participate citing a lack of a STEM program or not enough time to complete the study.

After little success with sending emails and calling the schools on the original list of 150 schools, a decision was made to create a short video for recruitment into the study and email that video to a larger sample of high schools. The video was created citing statistics on spending for scientific research and the need for STEM workers in the near future, and was sent to a list of over 300 school principals. The recruitment email was shortened to one paragraph identifying the main purpose of the study and asking the principal to contact the investigator if interested in participating. The language within the recruitment email also changed from “STEM School Culture” to “School culture in science and mathematics” to ensure that principals did not rule out participation because they did not have a STEM program. In addition, a sample report was sent to schools to show the type of data the school would receive upon participation in the study. A copy of a portion of the sample report indicating strengths and areas of improvement for schools can be found in Appendix L. Responses were received from 42 of those emails, with 5 of those contacted manifesting interest in participation.

During the spring of 2014, two schools agreed to participate in the study, and completed their senior survey in that time period. Those schools were Fisk High School in the Western part of the US and Rice High School in the Midwestern part of the US, with all school names being pseudonyms. Data were collected from these schools with the intent to complete the School STEM Culture survey in the Fall of 2014. In the Fall of 2015, two more schools agreed to participate in the study: Williams High School in the northeastern part of the US, and Varitek High School in the southeastern US. An effort was made to contact more local schools with the offer that the author would come to the school to collect data from students and teachers to make the process easier on the school. After these contacts to 15 more schools, three more schools in the southeastern part of the US agreed to participate: Boggs High School, Ortiz High School, and Martinez High School. Data were retained from Evans High School from the pilot study, which made eight total high schools participating in the study.

Data collection. A separate survey was given to a sample of seniors of each participating school requesting information on their plans after high school. The students were asked to identify whether they planned to attend a 2/4 year college, enter the military, or go straight into the work force. The survey then asked students to select from a list of 12 possible fields of study that they were most interested in pursuing. Students were also asked to complete an open- ended question regarding which college major or field of work they planned to pursue. Once the senior surveys were completed, results were analyzed and a percentage of seniors intending to pursue STEM fields was calculated for each school. Students were identified as pursuing STEM or not pursuing

STEM based on their choice of fields of study and their identified major or field of work. These results were used to calculate the percentage of seniors pursuing STEM fields.

The instrument was administered to a sample of stakeholders at the school determined by the administration of the school along with the survey of post-secondary plans. An attempt was made to have a sample of 30 teachers, 50 students taking the culture instrument, 50-100 seniors taking the post-secondary plans survey, all administrators and counselors, and 30-40 parents for each school. Some schools had difficulty recruiting parents to participate, so two of the eight schools had very small samples of parents.

Data analysis. Once the data were collected from the STEM-CAT and the Senior Survey, the percentage of seniors pursuing STEM fields was calculated using the data collected from the Post-Secondary Plans survey completed by current seniors at each participating school. The seniors selected their intended cluster of study from a list of 14 clusters as defined by the South Carolina Economic Development Act. Students were also given an opportunity to identify their intended field of study or work in a text box. The researcher sorted responses by cluster, and identified students as STEM or NOT STEM according to their cluster and field of study/work. The percentage of students pursuing STEM fields was then calculated by dividing the number of students pursing STEM by the total. The author was conservative when identifying STEM fields if it was not obvious. For example, if the student indicated the intent to go into auto-body work, this was not defined as a STEM field even though many STEM concepts are present in auto-body work.

After collecting data from the administration of the STEM-CAT to stakeholder groups for each of the eight school communities, the issue of weighting for each stakeholder group was addressed. Because there is no precedent set in the literature regarding how to weight each stakeholder group, two analyses were done. The first analysis, referenced as the *Item Response Equality Analysis,* maintained the equality of every response in the completion of the STEM-CAT. The second analysis, referenced as the *Stakeholder-Domain Equality Method*, maintained the equality of domains within stakeholder groups when calculating the total Positive Response Rate of the school community.

Item response equality method. In the Item Response Equality Method, each response to each item was considered to have equal value in the determination of the overall culture of the school. This provided each individual equal contribution to the overall Positive Response Rate score for that school, allowing for each individual student to have as much weight as the principal of the school. This method allowed for more input from individuals, but also might bias the results in favor of larger groups such as students or parents.

The calculation of the Total Positive Response Rate for each school using the Item Response Equality Method took the number of positive responses from all items, and divided that value by the total number of responses. This method allowed each respondent to have equal weight in the calculation of school-wide Positive Response Rate.

Stakeholder-domain equality method. Each stakeholder group makes a significant contribution to the culture of the school community (Franco, Patel, & Lindsey, 2012), Although the student and parent groups are much larger than the others, the sphere of influence of the individual teachers and members of school leadership may be larger, which could conceivably account for the smaller *N* for these groups due to the stability of these groups over a longer period of time. For example, a student or parent often interacts with the community for a time period of up to four years, while the teacher, counselor, or administrator is often a part of the culture for a longer period of time. This gives the teachers and school leadership a longer time period to affect the culture of the school. Considering the gap in the literature to quantify the amount each group contributes to the culture, it was assumed that each stakeholder group would contribute an equal amount to the culture.

The calculation of the Total Positive Response Rate for each school using the Stakeholder-Domain Equality Method took the average PRR for each stakeholder group from all domains. The average PRR between stakeholder groups was then calculated and used as the Total PRR for each school. This method allowed for each stakeholder-domain combination to have equal weight in the calculation of school-wide Positive Response Rate.

Correlation analysis. Using both methods of calculating the Total PRR for each school, the results from the STEM-CAT were used to correlate the percentage of seniors pursuing STEM fields to the total PRR for each school. Neutral responses were not counted as positive responses. This positive response rate (PRR), both for individual stakeholder groups and for the total school population, was correlated to the percentage of seniors planning to pursue STEM fields. A positive correlation would indicate that the construct of STEM culture was a valid construct and that the survey accurately measures that construct.

Using the data collected through the STEM-CAT and the Senior Survey, a scatterplot was created showing the overall Positive Response Rate for each school plotted against the percentage of seniors pursuing STEM fields. A bivariate correlation was run using SPSS (v 22.0) using Pearson's Correlation Coefficient (Hinkle, Wiersma, & Jurs, 2003). A p level of less than 0.05 was considered a significant result. After running the bivariate correlation between the total PRR and Percentage of seniors pursuing STEM fields using the Item Response Equality Method, bivariate correlations were also run using the PRR of individual stakeholder groups including parents, teachers and students. The school leadership group was not run because of the small N for this group for each school.

Multiple linear regression. The purpose of a bivariate correlation analysis is to determine if two variables have some relationship. The use of a multiple linear regression analysis determines if several factors might predict an dependent variable. For further analysis of the data, a multiple linear regression was attempted using both the Item Response Equality Method and the Stakeholder-Domain Equality Method of calculating the total PRR. A stepwise multiple linear regression was attempted for each set of data.

CHAPTER FOUR: RESULTS

The purpose of this investigation was to develop an instrument to measure School STEM Culture as defined as the beliefs, values, practices, resources and challenges within a school community as perceived by the parents, students, teachers, and school leadership. Once an instrument is created to measure school STEM culture, schools may use the tool to affect change within the culture, while always keeping in mind that this measurement is based on the perceptions of the stakeholders within the school. The STEM-CAT is an instrument that was designed to measure the STEM culture within a school community. This instrument was created via focus group review of initial items, an expert review of items, and a pilot reliability study of the initial items done within local high school. In the final phase of this study, the concept of school STEM culture construct was supported using eight high schools that agreed to participate in the study, and correlating the results of the STEM Culture Survey to the percentage of seniors at each school reporting an intention to pursue STEM fields upon graduation.

The results of the study align with each of the four phases of the study:

- Phase 1- Initial Item Design/Focus Group
- Phase 2- Expert Review
- Phase 3- Pilot Study
- Phase 4- Construct Validity

Phase 1: Item Design/Focus Group,

Initial item design. Items to be considered for the STEM-CAT were initially developed either by the author or by using existing items from surveys intended to measure one of the five domains of *beliefs, values, practices, challenges* and *resources*.

Items in the *beliefs* domain were used from the existing BARSTL instrument (Sampson, 2013) in addition to several items that were written based on the review of literature. Items for the four other domains were written based on review of the literature since no existing instruments were applicable.

After the initial writing of items, a focus group composed of graduate students in science education (2), mathematics education (2) and educational leadership (1) reviewed each item based on the ability to measure the sub-construct, and clarity of the item. Items were placed on a scale of 1-3, with 3 being a very strong item as far as the clarity of the item and the ability of the item to measure the sub-construct at hand, and 1 being a weak item. As each item was reviewed the focus group also identified the appropriate target stakeholders for each item using the classification of "all," "adults," "school adults," or by identifying an individual stakeholder group for that item. Tables showing the ranking of each item as well as the focus group's identification of the appropriate audience for the item for each of the five sub-constructs for School STEM Culture can be found in Appendix A.

Items from the initial list were retained to be sent for expert review based on the findings of the focus group. In the *beliefs* section, any items that received a rating of 1 out of 3 were removed (items 23, 37, 40, 55, 56, 57, 58, 59, 60, 61, 62, 66 and 69). Items that received a rating of 2 out of 3 were removed if the item topics were covered in a higher ranked item (9, 10, 17, 25, 32, 39, 49 and 53). Although it was rated a 3, item 13 was removed because it was wordy and a similar idea was addressed in item 12. Items 52 and 64 were also rated a 3 by the focus group, but were removed because they were very similar to questions 51 and 63 respectively. Items 3 and items 6-10 in the *values* section were all rated a 3 by the focus group, so the remaining items were removed in an effort to maintain parsimony of the survey.

In the section regarding *resources*, items 8, 20, and 25 were removed because they were rated a 1 out of 3 by the focus group, while item 11 was retained despite its rating of 1 because it asked about group size in classroom activities from the perspective of the adults in the school citing a specific size of three students per group in cooperative activities. It was felt that this item was important to determine if group size was important to the people within the school. Items 7 and 19 were removed with ratings of 2 out of 3 because they were repeating concepts from previous questions. After some discussion by the focus group, item 18 was removed despite a rating of 3. The item asked about field trips in STEM fields with no indication if the field trips were actually taken. If the trips were offered and not taken, then the true value of the field trip would be in question.

The initial list of items pertaining to *challenges* was fairly small, and all the items were dependent on each other; therefore, all items were retained. The challenges items were all focused on adults because students rarely participated in school level decisions regarding changes made due to current challenges.

Items 4, 18, 31 and 37 in the *practices* section were removed because they were rated a 1 out of 3 by the focus group. Items 15, 16 and 23 were removed with a 2 out of 3rating because they were repetitive with other higher ranked questions. In total, 42 items were removed before sending the list of items to the expert review.

Phase 2: Expert Review

After phase 1, which entailed initial item creation and focus group review, the remaining items were separated and configured into four separate lists with one list for each stakeholder. The lists were put into Microsoft Excel and sent to experts in science education (2), mathematics education (2), engineering education (2), digital media (2), and instrument development (1). Experts were asked to rate individual items on a scale of 1-9 using the following criteria:

9: A 9 should be an item that there is no doubt that it clearly and effectively measures the sub-construct at hand.

7: A 7 should be an item which you feel effectively measures the construct, but may leave some doubt based on wording, or understanding of the sub-construct.

5: A 5 should be an item which could measure the construct effectively, but the relationship between the item and the sub-construct is not completely clear to you.

3: A 3 should be an item which has a significant issue keeping it from measuring the sub-construct but could be improved by changing the wording.

1: A 1 indicates an item that completely misses the main idea of the construct.

The experts were asked to input their ratings on the Excel file and return the file with the saved ratings. The Excel file had a space for one rating for clarity and one rating for the ability of the item to measure the domain at hand. Prior to rating items, experts were provided a short PowerPoint with a summary of each domain to guide them in their review. Each expert reviewer analyzed four item lists, one for each stakeholder. If an item was repeated between stakeholders, it was blocked off so they would not be rated more than once by the reviewer.

Parent item review. Once the expert reviews were returned, analysis was run on the ratings for each item. A rating system to determine whether an item was considered valid or invalid was developed, using a benchmark rating of 7 and above as a "valid" item in the realm of clarity and construct validity. Based on the definition provided to the expert reviewers, it can be assumed that if the reviewer rates an item a 7, he or she believed that item to be a valid measure of the sub-construct intended; therefore, a rating of 7 was used as the cutoff for validity. The number of items above seven was determined, and divided by the total number of ratings (9) to determine a Content Validity Index (CVI) and a Clarity Index (CLI). Consequently, each index was a number between 0 and 1. Items with either a CVI or CLI below 0.75 were removed (Yaghmale, 2003). Starting with the parent items for *beliefs*, Table 4.1 indicates which items were removed after expert review along with the CVI and CLI for each item.

Table 4.1

Parent Beliefs Items Removed after Expert Review

Items for Beliefs Domain	CVI	CLI
2. Students create their own knowledge by modifying their existing ideas in an effort to make sense of new and past experiences.	0.44	1.00
4. Students have difficulty learning science and mathematical concepts in school because their beliefs about how the world works are often resistant to change.	0.56	0.67
19. To prepare students for college and careers in STEM fields, the curriculum should cover as many different topics as possible over the course of a school year.	1.00	0.56
22. During a lesson, teachers should present material clearly using some type of visual aid such as PowerPoint or lecture notes.	0.78	0.56
25. Students should learn at different paces and in different ways within the same classroom.	0.56	0.67
30. Some people are not science people and should avoid taking science courses.	0.56	0.89
31. Some people are not mathematics people and should avoid taking mathematics courses.	0.56	0.89

In the expert review for parent items, no items were removed for *resources* because all the items maintained a CVI and CLI above 0.75. Because there were only six items, all of the items were retained. In the section on *values*, item 2 had some issues with the CVI and CLI. Table 4.2 indicates the ratings for each part of the item based on the expert review. Although rankings for the stem of the item were low (CVI of 0.44, CLI or 0.33), many parts of the item scored above 0.75 for both indices. This indicates that the experts may not have followed that the stem applied to the parts of the item until after, and never went back to change the stem rating. Parts of the item which have a CVI and CLI above 0.75 were retained, removing parts d and h. Part b was retained because of the relationship between student goals and their relationship with STEM courses and part a was retained to relate the learning to the outside world.

Table 4.2

Parent Items-CVI and CLI for Values Items

Items for Values	CVI	CLI
2. *Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).*	0.44	0.33
a. To accumulate knowledge about the world around us.	0.67	0.89
b. To prepare for college/university studies only if the courses apply to their major or career.	0.67	0.56
c. To be able to have an educated debate about policies in our community.	0.89	0.89
d. To be able to understand issues in the government when voting.	0.56	0.78
e. To understand how concepts are used to assist in their desired way of life.	0.78	0.78
f. To be able to make educated decisions about moral and ethical issues in current events.	0.78	0.89
g. To be able to understand the issues in current scientific research.	0.78	0.89
h. To understand how technology is developed for the future.	0.56	0.89

In an effort to maintain parsimony in the *beliefs* section of the parent survey, additional items were removed. Beliefs regarding STEM culture are broken down into four sub-constructs, including beliefs about the way people learn, lesson design, the teacher and learning environment and the nature of STEM. To reduce the number of items while still maintaining the ability to measure each sub-construct, the number of items per sub-construct within beliefs was reduced to four to six items. After the expert review, remaining items were organized based on which sub-construct under beliefs they fell under. Items that were considered ***beliefs about the way people learn*** were identified with a "1," ***beliefs about lesson design*** were identified with a "2," ***beliefs about the teacher and learning environment*** were identified with a "3," and ***beliefs about the Nature of Math or Science*** were identified with a "4." The items were sorted based on their sub-construct and reviewed by the author. Items 1, 3, 15, 16, 23, 26, 28, 29, 32, 34, 35, 36, 37 and 38 were identified in group 1 indicating that they were intended to measure beliefs about the way people learn. Once items were identified in group 1, they were then sorted in order of CVI first, then in order of CLI. Content validity (CVI) was addressed first because it is more likely that clarity could have been adjusted before the survey is published. Items 1, 3, 28, 36, 37, 32, 38, 35, 15 and 34 were removed because they were redundant. Other items that were rated higher on CVI and CLI asked similar questions to get at the same aspect of the sub-construct. Items 3, 28, 36, 37, 32, 38 and 35 were all focused on the belief that either all students can be successful in STEM fields, or the belief that students are either good at STEM courses or they are not. Table 4.3 indicates the items which were redundant for this concept, and shows the item which was retained.

Table 4.3

Redundancy for Items Within Parent Beliefs about the Way People Learn

Concept:
People within a school culture may either believe that ability within STEM courses is innate and cannot be changed, or they may believe that all students have the ability to be successful in STEM courses if they work hard enough.

Retained item:
29. There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.

Redundant Items (removed):
3. People are either talented at science or they are not, therefore student achievement in science is a reflection of their natural abilities.
28. All students can learn science and mathematics if they try hard enough.
36. Anyone can be successful in STEM careers.
37. A girl can become the CEO of a major engineering industry.
32. Every student in a school can learn calculus if they try hard enough.
38. Someone who is a minority can become the CEO of a major industry.
35. Certain races or genders are better at STEM classes than others.
34. People involved in STEM careers must be enrolled in Advanced Placement courses in high school.

Concept:
Students enter a STEM classroom either as a blank slate for teachers to construct knowledge within, or with pre-existing knowledge that a teacher can use as a starting point to create new knowledge.

Retained Item:
23. Students should build their knowledge upon things they have learned in the past.

Redundant Item (removed):
1. Students develop many beliefs about how the world works before they ever study about science in school.

Concept:
Learning in a STEM classroom should either be teacher-centered, where the teacher is the disseminator of information for students to receive, or student centered, where the teacher facilitates learning and the student takes ownership.

Retained Item:
16. STEM teachers should primarily act as a resource person, working to support and enhance student investigations rather than explaining how things work.

Redundant Item (removed):
15. An excellent STEM teacher is someone who is really good at explaining complicated concepts clearly and simply so that everyone understands.

The deletion of repetitive items led to retention of items 29, 26, 16 and 23 to measure beliefs about the way people learn. Only four items (5, 8, 24, 13) were included to measure beliefs about lesson design, and all four items were retained. Seven items were grouped together to measure beliefs about the teacher or learning environment. Items 6 and 10 were removed. Item 6 had a CVI of 0.67 which was below the accepted value of 0.75, and therefore it was removed. Item 10 had a CLI or 0.78, and seemed to be much lengthier than the rest of the items and thus was removed. Items 27, 33, 9, 11 and 12 were retained regarding beliefs about the teacher and learning environment. Regarding the Nature of Science and Mathematics, items 14, 7, 20 and 21 were retained. Item 18 was removed because it was redundant with item 21 as shown in Table 4.4

Table 4.4

Redundancy for Items within Parent Beliefs about the Nature of Science and Mathematics

Concept: In scientific communities, research is done using one defined scientific method which is always the same and follows a very specific set of steps beginning with “define the problem” and ending with “reporting the results.”
Retained item: 21. Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with ‘define the problem’ and ends with ‘reporting the results.’
Redundant Items (removed): 18. Students should know that scientific knowledge is discovered using the scientific method.

Although item 21 had a lower CLI than item 18, the author preferred to keep the language “science is based on a single scientific method” to determine if the stakeholder’s belief was that only one scientific method exists. Item 17 was removed due to a CVI of 0.67. After the removal of items by the author, this reduced the total number of beliefs items for the parent survey to 17 items.

A sample of the final item list for the Parent Survey after the expert review can be found in the Appendix B. Each item was renumbered and formatted into an online survey form which could be sent out to participants. An informed consent letter about the study was placed at the beginning of the survey, and a question was added asking for the name of the affiliated school in order to keep schools separate in the results.

School leadership item review. To maintain consistency between surveys, the items for the *beliefs* section for each of the adult stakeholders was kept the same. This removed items 4, "Students learn the most when they are able to explore, discuss, and debate many possible solutions during group activities in STEM courses," and item 18, "A STEM curriculum should encourage students to learn and value alternative modes of investigation or problem solving" on the school leadership expert review. Although these items scored high on the expert review (0.89 and 1.00 for item 4, 0.78 and 1.00 for item 18), the consistency of the items between each survey was determined to be important for the reliability study so those items were not added to the survey for the school leadership. The *values* section for school leadership did not contain any items not contained in the parent section, so the final items for the *values* section remained the same as the parent section as well.

In the *resources* section of the school leadership items, the original 15 items were reduced to 9 final items based on the original sub-constructs. The CVI and CLI for each item was calculated using the respective formulas, and each item was identified to match one of three sub-constructs for resources, with a "1" noting an item focusing on *financial resources*, a "2" noting an item focusing on a *community resources* and a "3" noting an item focusing on *material resources*. Table 4.5 indicates the ratings and sub-construct for each item under *resources* for the school leadership survey.

Table 4.5

School Leadership Items-CVI and CLI for Resources Items

Item	CLI	CVI	Sub-Construct
1. Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management.	0.89	0.89	1
2. The class sizes in STEM classes are below the state average.	0.78	0.78	1
3. I am satisfied with the size of classes in my school.	1.00	0.78	1
4. STEM teachers in my school are paid above the state average.	0.89	0.67	1
5. Teacher salaries in my school are too low for the area in which we live.	0.89	0.78	1
6. The classrooms in my school building are large enough to teach without being crowded.	0.78	0.89	1
7. STEM teachers have the resources to do activities in their classrooms with groups of 3 or less.	0.44	0.78	3
8. Representatives of our school meet with business and community members to discuss STEM related community issues.	0.89	1.00	2
9. I have opportunities to discuss curriculum with business/industry members in my community.	1.00	1.00	2
10. Our school offers extra-curricular activities in STEM which involve business/industry members.	0.89	1.00	2
11. Teachers in my school have access to sufficient resources to complete activities/labs.	0.78	0.78	3
12. STEM teachers skip labs/activities when they do not have access to the necessary materials.	0.89	0.89	3
13. Teachers often purchase materials for activities/labs with their own money.	1.00	0.89	1
14. There is sufficient access to technology in classrooms for curricular purposes.	0.67	0.89	3
15. Students in my school have access to everyday materials such as pens, pencils and calculators.	0.89	0.78	3

To minimize the total number of items while maintaining the reliability of the survey, three items for each sub-construct were kept. Items 2, 3, 6, and 11 were removed due to redundancy with other items on the list which scored as well or higher on the expert review with redundancy reported in Table 4.6

Table 4.6.

Redundancy for Items within School Leadership Resources Items

Concept: Are the classrooms and number of students within the classroom acceptable in order to effectively teach STEM subjects? *Retained item:* 1. Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management. *Redundant Items (removed):* 2. The class sizes in STEM classes are below the state average. 3. I am satisfied with the size of classes in my school. 6. The classrooms in my school building are large enough to teach without being crowded.
Concept: Do teachers have access to a sufficient amount of materials to complete hands on activities with manageable group sizes? *Retained item:* 12. STEM teachers skip labs/activities when they do not have access to the necessary materials. *Redundant Items (removed):* 11. Teachers in my school have access to sufficient resources to complete activities/labs

Item 4 was removed because the expert review yielded a CVI of 0.67 and three of the other items measuring the financial resources scored higher. Item 7 was removed because the CLI of the item was a 0.44 showing that the item had a major issue with clarity. Items 1, 5, 8, 9, 10, 12, 13, 14 and 15 were retained in the final survey for school leadership.

In the *challenges* section of the school leadership survey, the items follow the progression of the process that a school would take to handle challenges as identified in the literature review. Therefore, it was important to retain each item if possible. Items 1 and 4 scored high on CVI, but scored 0.67 on the CLI. Both items were rewritten to improve the clarity and retain the items. Item 1 was reworded to improve the clarity, with the new wording on the item to read as follows: “My school regularly monitors and identifies any challenges to our science, math, engineering and technology program.” The intent of this item was to determine if the school leadership is constantly reflecting on the STEM program looking for challenges that could make the program better; by adding the word “monitors” the participants could reflect on whether there was a constant awareness of upcoming challenges. Some items were reformatted to include wording that improved clarity; for example item 4 was reworded to read as follows: “My school has implemented new programs to take on our challenges in science, math, engineering and technology.” The intent of this item was to determine if the school was making changes to adapt to any challenges they experienced. The wording “has implemented our program” was ambiguous and did not lead the participant to understand which program the survey was referring to. By changing the language to “has implemented new programs,” the focus remained on the challenge and allowed to the participant to reflect on that challenge. Table 4.7 indicates the ratings and sub-construct for each item under resources for the school leadership survey.

Table 4.7

School Leadership Items-CVI and CLI for Challenges Items

Item	*CLI*	*CVI*

1. My school has identified challenges to our science, math, engineering and technology program.	0.67	0.89
2. When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	0.78	0.78
3. My school involves students and parents in developing our science, math, engineering and technology program.	0.78	0.78
4. My school has implemented our program to take on our challenges in science, math, engineering and technology.	0.67	0.89
5. My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	0.78	0.89
6. After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	0.78	0.89

The section on *practices* for the school leadership participants only had four initial items. Of those four items, three were retained. Table 4.8 indicates the ratings and sub-construct for each item under practices for the school leadership survey. Item 3 was removed despite having a CLI and CVI or 0.78 because in the expert review for teacher items, the same item was rated a 0.67 for both CLI and CVI. Because of this discrepancy, the item was removed.

Table 4.8

School Leadership Items-CVI and CLI for Practices Items

Item	*CLI*	*CVI*
1. Math teachers work together to develop lessons.	0.89	0.89
2. Science teachers work together to develop lessons.	0.89	0.89
3. Math and science teachers in my school think the other math and science teachers do a good job.	0.78	0.78
4. Teachers are free to make the instructional decisions in STEM classes.	0.89	0.89

A sample of the final item list for the School Leadership Survey after the expert review can be found in B. Each item was renumbered and formatted into an online survey form that could be sent to participants. An informed consent letter about the study was placed at the beginning of the survey, and a question was added asking for the name of the affiliated school to keep schools separate in the results.

Teachers item review. The survey for teachers is identical to the survey for school leadership with the exception of the section on *practices*. The items retained for the previous two surveys were also retained for the teacher survey as well. From the initial list of seven items for practices, two items were removed. Item 1 was removed because both items 1 and 2 asked if teachers determined prior knowledge before instruction, and item 1 scored the same CLI and CVI as item 2. Item 1 was removed because the phrase "existing knowledge" was consistent with the information in the literature review. Item 6 was removed because the CLI and CVI were rated at 0.67. Table 4.9 indicates the ratings and sub-construct for each item under practices for the teacher survey.

Table 4.9

Teacher Items-CVI and CLI for Practices Items

Item	*CLI*	*CVI*
1. Math and science teachers ask students what they know about a topic before they begin to study the topic.	0.89	0.78
2. Math and science teachers use a student's existing knowledge to help build new knowledge.	0.89	0.78
3. In STEM classes, students engage in hands-on activities after the material has been taught.	0.78	0.78
4. Math teachers work together to develop lessons.	1.00	0.89
5. Science teachers work together to develop lessons.	1.00	0.89
6. Math and science teachers in my school think the other math and science teachers do a good job.	0.67	0.67
7. Teachers are free to make the instructional decisions in STEM classes.	0.78	0.78

A sample of the final item list for the Teacher Survey after the expert review can be found in Appendix B. Each item was renumbered and formatted into an online survey form which could be sent out to participants. An informed consent letter about the study was placed at the beginning of the survey, and a question was added asking for the name of the affiliated school in order to keep schools separate in the results. A question was also added asking which subject area the teacher focuses on for the majority of each day.

Student item review. In the section for beliefs, the student survey did not contain three of the original items contained in the surveys for parents, school leadership, and teachers. Those three items (items 5, 20 and 33) were replaced with three new items from the student survey. Table 4.10 indicates the ratings for each item under beliefs for the student survey.

Table 4.10

Student Items-CVI and CLI for Beliefs Items

Item	*CLI*	*CVI*
1. I developed beliefs about scientific concepts before I ever studied science in school.	1.00	0.89
3. In STEM subject areas, a teacher must explain the concept in a way that is clear and easy to understand for a student to learn.	0.78	0.89
4. Students know very little about science and mathematics before they learn it in school.	0.67	0.89
6. When students conduct an experiment during a science lesson, the teacher should give step-by-step instructions for the students to follow in order to prevent confusion and get the correct results.	0.89	0.89
33. When someone makes a claim that something is true, they must present evidence to support their claim.	0.89	0.89
34. People should accept what I tell them without asking for proof.	0.67	0.78
35. There are certain classes that my parents discourage me from taking because I might not be successful.	0.67	0.67
36. My counselors encourage me to take advanced STEM courses that might be difficult for me.	1.00	0.89

37. My counselors tend to push me away from STEM courses because I am weak in math and science.	1.00	0.89
38. In the past, I have avoided signing up for a difficult STEM course because my peers told me not to.	1.00	0.89

Items 33, 36 and 38 were the items that were retained from the list. Items 1, 3, 4 and 6 were redundant with items that were already included in the survey as shown in Table 4.11

Table 4.11

Redundancy for Items Within Student Beliefs Items

Concept:
Students enter a STEM classroom either as a blank slate for teachers to construct knowledge within, or with pre-existing knowledge that a teacher can use as a starting point to create new knowledge.

Retained Item:
23. Students should build their knowledge upon things they have learned in the past.

Redundant Item (removed):
1. I developed beliefs about scientific concepts before I ever studied science in school.
4. Students know very little about science and mathematics before they learn it in school.

Concept:
Learning in a STEM classroom should either be teacher-centered, where the teacher is the disseminator of information for students to receive, or student centered, where the teacher facilitates learning and the student takes ownership.

Retained Item:
16. STEM teachers should primarily act as a resource person, working to support and enhance student investigations rather than explaining how things work.

Redundant Item (removed):
3. In STEM subject areas, a teacher must explain the concept in a way that is clear and easy to understand for a student to learn.
6. When students conduct an experiment during a science lesson, the teacher should give step-by-step instructions for the students to follow in order to prevent confusion and get the correct results.

Items 34 and 35 each had a CLI rating of 0.67 indicating that the items had clarity issues. Item 37 was a negatively coded version of item 36, the positively coded version was chosen to avoid trying to "push" the student in a certain direction with the negative wording.

The *values* section of the student survey retained the same items as the previous three surveys. There were initially four more items on the student survey that asked about the students' awareness of the four STEM fields. Each of these items was rated low for CLI and CVI by the experts, and therefore each of the items was removed. Table 4.12 indicates the ratings for the awareness items under values for the student survey.

Table 4.12

Student Items-CVI and CLI for Values Items

Item	*CLI*	*CVI*
3. I would identify my relationship with science as	0.44	0.56
a. I am aware of science, but it is not relevant to my world.		
b. I accept that science is important.		
c. I like science and enjoy participating in science.		
d. I seek out scientific activities for enjoyment.		
e. I am considering a science field in the future.		
4. I would identify my relationship with mathematics as	0.44	0.56
a. I am aware of mathematics, but it is not relevant to my world.		
b. I accept that mathematics is important.		
c. I like mathematics and enjoy participating in mathematics.		
d. I seek out mathematic activities for enjoyment.		
e. I am considering a mathematics field in the future.		
5. I would identify my relationship with engineering as	0.44	0.56
a. I am aware of engineering, but it is not relevant to my world.		
b. I accept that engineering is important.		

c. I like engineering, and enjoy participating in engineering.		
d. I seek out engineering activities for enjoyment.		
e. I am considering a engineering field in the future.		
6. I would identify my relationship with technology as	0.44	0.56
a. I am aware of technology, but it is not relevant to my world.		
b. I accept that technology is important.		
c. I like technology and enjoy using or developing new technologies.		
d. I seek out new technologies for enjoyment.		
e. I am considering a technology field in the future.		

The *resources* section of the student survey initially contained 10 items when submitted for expert review. Item 2 was removed because it was redundant as it was addressed in item 1, and although item 2 had a higher CVI it was felt that the perspective of item 1 was more on the student level so it was retained. Item 3 was removed because it was redundant with item 4, and item 4 had a higher CLI so it was retained. Redundancy issues for these items can be found in Table 4.13

Table 4.13

Redundancy for Items Within Student Resources Items

Concept: Are the classrooms and number of students within the classroom acceptable in order to effectively teach STEM subjects? *Retained item:* 1. Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching. *Redundant Items (removed):* 2. I am satisfied with the size of classes in my school.
Concept: Do teachers have access to a sufficient amount of materials to complete hands on activities with manageable group sizes?

Retained item:
4. I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials.

Redundant Items (removed):
3. I often work in groups larger than 4 in my STEM courses because of lack of materials.

Items 5 and 6 both had CLI ratings of 0.56, so they were both removed, while items 8, 9 and 10 were retained for a total of 5 remaining items. Table 4.14 indicates the ratings for the items under resources for the student survey.

Table 4.14

Student Items-CVI and CLI for Resources Items

Item	*CLI*	*CVI*
1. Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching.	0.89	0.78
2. I am satisfied with the size of classes in my school.	0.89	0.89
3. I often work in groups larger than 4 in my STEM courses because of lack of materials.	0.78	0.78
4. I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials.	0.89	0.78
5. My school has engineering and technology programs which use expensive materials.	0.56	0.78
6. My school only offers the typical mathematics and science courses.	0.56	0.78
7. Our school offers extra-curricular activities in STEM which involve business/industry members.	0.89	1.00
8. Teachers in my school have access to sufficient resources to complete activities/labs.	0.78	1.00
9. We have technology in my classroom, but students never get to use it.	0.67	0.78
10. Students in my school have access to everyday materials such as pens, pencils and calculators.	1.00	0.89

The *practices* section in the student survey initially contained 27 items. To reduce the number of total items while maintaining the ability to measure each sub-construct in the domain, the number of items was reduced to 11. Item 1 was removed due to redundancy with item 2, while item 2 had a rating of 1.00 for both CLI and CVI, while items 2, 3, 4 and 5 were retained with all applying to the sub-construct of practices regarding planning and connecting learning to some application outside of the classroom. Items 6, 8 and 9 were retained for their application to eliciting student ideas through practice. Formative assessment in the classroom was addressed in item 6, so items 7, 10 and 11 were removed for redundancy. Although items 7, 10 and 11 contained acceptable CLI and CVI ratings, item 6 was worded in a way that focused on the student, which is why it was retained. Item 12 was retained as the only item referring to the practice of making sense of material activities. Item 13 was removed because asking if students complete hands-on activities did not indicate that the teacher helped students make sense of those activities, and the focus of the sub-construct was the teacher's ability to help students connect hands-on activities to the content. The focus of items 16, 17, 18 and 26 was on the practice of using evidence based arguments, and they were retained. Item 15 was removed due to redundancy with item 16, and item 16 scored higher on CLI and CVI, while items 22 and 23 each had CVI lower than 0.6 and were removed. Items 19, 20, 21, 24, and 25 were all redundant questions asking the same basic concept from the retained items. The literature review does not discuss motivation to pursue STEM fields within strong STEM practices; therefore, item 27 was removed. The items were retained due to their higher score on the CLI and CVI. Table 4.15 indicates the ratings for the items under practices for the student survey and Table 4.16 indicates redundancy issues within the sub-construct.

Table 4.15

Student Items-CVI and CLI for Practices Items

Item	*CLI*	*CVI*
1. My science and math teachers begin units/lessons with an essential question and refer to that question throughout the entire unit/lesson.	0.78	1.00
2. When my science and math teachers are teaching, they talk about how concepts connect to the real world.	1.00	1.00
3. I struggle to understand what my teachers are teaching in science and math because I do not see how it applies to me.	0.78	0.78
4. My science and math lessons begin with an interesting idea that gets me involved in the lessons.	0.89	1.00
5. My math and science lessons begin with a review activity from the class before.	1.00	0.89
6. My math and science teachers ask me what I know about a topic before we begin studying the topic.	1.00	0.78
7. My math and science teachers use my existing knowledge to help me build new knowledge.	0.89	0.78
8. When my math and science teachers begin a new unit, they act as if I do not have any previous understanding of the concepts.	0.89	0.89
9. My math and science teachers check with me to make sure I have a good understanding of concepts.	1.00	0.89
10. My math and science teachers work hard to ensure that all students progress at the same pace.	1.00	0.89
11. My math and science teachers begin a unit with some type of pre-assessment.	0.89	0.78
12. In STEM classes, students engage in hands-on activities after the material has been taught.	0.78	0.78
13. In my math classes, we do hands on activities.	1.00	0.89
14. Homework in my math classes consists of a large number of practice problems.	1.00	0.78
15. When problem solving in math, we solve problems to get the correct answer from the book.	0.78	0.78
16. When solving problems in math class, we solve problems related to real life scenarios.	0.89	1.00
17. My teachers ask me to justify my answers in STEM classes.	0.89	0.89
18. In my math and science classes, I have to explain concepts to other students.	0.78	1.00
19. In my math and science classes, I have to justify my ideas to other students.	0.89	1.00
20. I work in groups to solve problems in my math	0.89	1.00

classes.		
21. I work in groups in my science classes.	0.89	0.89
22. Math and science teachers in my school often know what the other teachers are doing.	0.78	0.56
23. Math and science teachers in my school think the other math and science teachers do a good job.	0.67	0.44
24. Based on my experiences in class, I have a good understanding of what it is like to do scientific research.	0.89	0.78
25. Based on my experiences in school, I have a good understanding of how an engineer develops a product.	0.89	0.67
26. I have had to defend a product or conclusion in my STEM classes.	0.89	0.89
27. My teachers in math and science motivate me to want to learn about STEM fields.	1.00	0.78

Table 4.16

Redundancy for Items Within Student Practices Items

Concept:
Do teachers plan lessons with a "big picture" in mind, connecting the learning to something concrete outside the classroom?

Retained item:
2. When my science and math teachers are teaching, they talk about how concepts connect to the real world.

Redundant Items (removed):
1. My science and math teachers begin units/lessons with an essential question and refer to that question throughout the entire unit/lesson.

Concept:
Do teachers elicit prior ideas from students at the beginning of a unit and use those ideas within their teaching?

Retained item:
6. My math and science teachers ask me what I know about a topic before we begin studying the topic.

Redundant Items (removed):
7. My math and science teachers use my existing knowledge to help me build new knowledge.
10. My math and science teachers work hard to ensure that all students progress at

the same pace.
11. My math and science teachers begin a unit with some type of pre-assessment.

Concept:
Do teachers of mathematics give practice problems which utilize mathematics to solve real world problems?

Retained item:
16. When solving problems in math class, we solve problems related to real life scenarios.

Redundant Items (removed):
15. When problem solving in math, we solve problems to get the correct answer from the book.

Concept:
Do teachers place students in group situations where the students must use evidence to explain certain concepts or ideas?

Retained item:
18. In my math and science classes, I have to explain concepts to other students.

Redundant Items (removed):
19. In my math and science classes, I have to justify my ideas to other students.
20. I work in groups to solve problems in my math classes.
21. I work in groups in my science classes.

Concept:
Are students placed in classroom situations where they model the scientific or engineering processes?

Retained item:
26. I have had to defend a product or conclusion in my STEM classes.

Redundant Items (removed):
24. Based on my experiences in class, I have a good understanding of what it is like to do scientific research.
25. Based on my experiences in school, I have a good understanding of how an engineer develops a product.

A sample of the final item list for the Student Survey after the expert review can be found in the Appendix B. Each item was renumbered and formatted into an online survey form that could be sent out to participants. An informed consent letter about the study was placed at the beginning of the survey in addition to a parent permission form that was sent ahead of the survey date. A question was added asking for the name of the affiliated school to keep schools separate in the results.

Phase 3: Pilot Study

Based on the results of the focus group and expert review, four separate item lists were created with one list for each stakeholder. The initial list contained 29 items for parents, 40 items for students, 43 items for teachers, and 41 items for school leadership. Most items were Likert style questions with an initial statement to which the respondents would indicate whether they strongly disagreed, disagreed, were neutral, agreed or strongly agreed. One question given to each group of stakeholders asked the respondent to indicate the level of importance of a variety of reasons to learn about STEM fields on a scale of not important to very important.

One local high school was used for the majority of the pilot study, with some teachers and school leadership being invited to participate from surrounding schools to make sure the sample size was large enough. Parents were invited to participate in the pilot study through a school-wide email list at the site of the pilot study, with 63 parents choosing to participate. Teachers were invited to participate during lunchtime departmental meetings at the main site, in addition to an email to other high school teachers within the same district as the main site, with 52 teachers choosing to participate. Administrators and counselors were invited from the district of the main site as well as a neighboring district to count as the school leadership group. Thirty-five school leaders participated in the survey through the online survey site. Students were invited to participate through their homeroom at the main pilot site. Of the 107 students who were invited to participate, 49% (n=53) returned their permission forms and came to complete the survey on the available day during their homeroom period. The pilot study was completed for the purpose of conducting an item reliability study, to identify unanticipated mistakes in the survey, and to test the data collection procedure. The survey took approximately 5-15 minutes for each participant. Some feedback was received of a spelling error in one of the questions; otherwise, data collection procedures were smooth.

Initial analysis was completed using Cronbach's Alpha as a measure of internal consistency for items within particular sub-constructs. Calculating alpha indicates the consistency between items within a sub-construct and determines the proportion of variance that can be attributed to each item for a particular sub-construct. Acceptability for alpha was set as follows for this study: below 0.7, unacceptable; between 0.7 and 0.75; minimally acceptable; between 0.75 and 0.8, acceptable; between 0.8 and 0.9, very good; above 0.9, consider shortening the scale (DeVellis, 2003).

Items within the "beliefs" construct were identical for all three adult groups of stakeholders: parents, school leaders, and teachers. Sub-constructs for "beliefs" were defined as (a) beliefs about how people learn, (b) beliefs about lesson design, (c) beliefs about the teaching and learning environment, and (d) beliefs about the nature of STEM. Cronbach's alpha was run for each group of stakeholders for each sub-construct within "beliefs." Of the 12 sub-construct/stakeholder combinations for which alpha scores were run, three contained an alpha that was minimally acceptable including Parent Beliefs about the Teaching/Learning Environment (0.766), Teachers Beliefs about the Teaching/Learning Environment (0.754) and School Leadership Beliefs about the Nature of STEM (0.717). School Leadership Beliefs about the Teaching/Learning Environment (0.844) was the only alpha calculated that was determined to be very good. Each of the categories had to be reduced to two items to obtain an acceptable alpha. Table 4.17 indicates the coefficient alpha for each of the adult sub-construct/stakeholder combinations within the beliefs domain.

Table 4.17

Coefficient Alpha for Adult Sub-constructs

Parents Beliefs	**Alpha**	**Items Removed**
How people learn	.430	1.9
Lesson Design	.523	1.2
Environment	.766*	1.7,2.2,2.7
NOS	.391	1.6, 2.4
Teacher Beliefs	**Alpha**	**Items Removed**
How people learn	.205	1.9,2.1
Lesson Design	.587	2.3,2.6
Environment	.754*	1.7,2.7
NOS	.510	1.5,1.6
School Leader Beliefs	**Alpha**	**Items Removed**
How people learn	.589	1.9,2.8
Lesson Design	.643	2.3,2.6
Environment	.844*	1.7,2.2,2.7
NOS	.717*	1.5,1.6

***Indicates an alpha level above the minimally acceptable range**

Due to the low reliability of the items within the sub-construct/stakeholder categories, Cronbach's alpha was determined for the entire group of adults combined. Results, found in Table 4.18, were similar to results for individual groups of stakeholders with the only acceptable alpha in the category of Beliefs about Teaching/Learning Environment (0.839), which was found to be very good. The number of items was reduced to two before an acceptable alpha was determined.

Table 4.18

Coefficient Alpha for Combined Adult Sub-constructs

All Adult Beliefs	**Alpha**	**Items Removed**
How people learn	.375	1.9,2.8
Lesson Design	.390	None
Environment	.839*	1.7,2.2,2.7

NOS	.319	1.5,1.6

**Indicates an alpha level above the minimally acceptable range*

Due to the low reliability coefficients within the adult categories of beliefs, a factor analysis was conducted to determine if items would stick together better in a different organizational pattern. The results from all three categories of adult responses were used since the items in each survey were identical. An exploratory factor analysis (EFA) was completed using the SPSS computer software package. A Kaiser-Meyer-Olkin Measure of sampling adequacy was .712, and Bartlett's Test of Spherecity was found to be significant ($p>.001$), which indicates that items in the survey were strongly correlated enough to conduct a factor analysis (Tabachnick & Fidell, 2001). Factors were extracted using maximum likelihood methods with oblique rotation (promax) because the factors were assumed to be related. The data presented were complete with no missing data; therefore, no reduction of data was necessary. A factor solution was obtained using Kaiser's criteria, the scree plot, the interpretability of the results, and the model fit indices as assessed by SPSS, which indicated a two-factor model (Preacher & MacCallum, 2003). The EFA was used to determine the retention or removal of items from the survey being analyzed (Worthington & Whittaker, 2006). Factors were removed if they did not load on at least three different survey items (Kahn, 2006). Items with a factor loading of .40 or higher were retained based on study criteria (Tabachnick & Fidell, 2001). Item B11 did not have a factor loading higher than 0.4, but was retained due to the nature of the item regarding the perception of ability in learning science and mathematics of students. This resulted in a final scale containing three factors and 15 items that can be found in Table 4.19.

Table 4.19

Summary of Exploratory Factor Analysis results for Parent, School Leadership and Teacher Beliefs using Maximum Likelihood (N=136)

	Beliefs about student activities in STEM courses	Beliefs about curriculum/ lesson design
B1_1- There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	.085	**.359****
B1_2- Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	-.077	**.546****
B1_3- Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**.465****	-.017
B1_4- In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**.447****	.069
B1_5- Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'	-.034	**.502****
B1_6- Investigations should be included in lessons as a way to reinforce the scientific and mathematical concepts students have already learned in class.	-.444	.103
B1_7- During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	-.017	**.495****
B1_8- Learning should be an orderly process, where students are presented material in a sequence to be remembered.	.003	**.737****

B1_9- STEM teachers should primarily act as a resource person, working to support and enhance student investigations rather than explaining how things work.	-.250	.150
B2_1- The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	.012	**.637****
B2_2- Students should be exposed to STEM careers during the school day.	**.713****	.031
B2_3- During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**.739****	.064
B2_4- Students should accept the ideas and theories presented to them during STEM classes without question.	.130	.092
B2_5- A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**.654****	.085
B2_6- Teachers should involve students in determining the direction and the focus of a lesson.	.298	-.168
B2_7- Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	-.200	**.411****
B2_8- Students should build their knowledge upon things they have learned in the past.	**.478****	-.118

Using the new sub-constructs determined by the exploratory factor analysis of "Beliefs about student activities in STEM courses" and "Beliefs about curriculum/lesson design," a reliability analysis was completed using Cronbach's Alpha. Combined results for all adult stakeholders and results for individual stakeholder groups from the reliability analysis are found in Table 4.20.

Table 4.20

Revised Coefficient Alpha for Adult Sub-constructs

Combined Adult Beliefs	**Alpha**	**Items Removed**
Beliefs about student activities in STEM courses	.815*	None
Beliefs about curriculum/lesson design	.714*	None
Parents Beliefs	**Alpha**	**Items Removed**
Beliefs about student activities in STEM courses	.762*	2.5, 2.8
Beliefs about curriculum/lesson design	.664	1.2, 2.7
Teacher Beliefs	**Alpha**	**Items Removed**
Beliefs about student activities in STEM courses	.823*	None
Beliefs about curriculum/lesson design	.696	1.1, 2.7
School Leader Beliefs	**Alpha**	**Items Removed**
Beliefs about student activities in STEM courses	.601	2.2,2.8
Beliefs about curriculum/lesson design	.769*	None

**Indicates an alpha level above the minimally acceptable range*

The results of the reliability analysis using coefficient alpha of the combined adult group support the reorganization of sub-constructs within the beliefs domain into two categories: beliefs about student activities in STEM courses (.815), and beliefs about curriculum/lesson design (.714). Cronbach's Alpha was then analyzed for individual stakeholder groups to determine if the items were reliable for each group. For the parent survey, items within the sub-construct of beliefs about student activities was retained with the alpha coefficient (.762) being in the acceptable level, while items within the sub-construct of beliefs about curriculum/lesson design were removed with the alpha coefficient (.664) in the unacceptable level. For the teacher survey, items within the sub-construct of beliefs about student activities was retained with the alpha coefficient (.823) being in the very good range. Items within the sub-construct of beliefs about curriculum/lesson design were retained despite an alpha coefficient (.696) in the unacceptable level. For the school leadership survey, items within the sub-construct of beliefs about student activities were removed with the alpha coefficient (.601) being in the unacceptable level, while items within the sub-construct of beliefs about curriculum/lesson design were retained with the alpha coefficient (.769) in the acceptable level.

Items within the student survey for beliefs were analyzed separately from the adult stakeholder surveys because some of the student items did not match the adult surveys. Cronbach's alpha was run for students for each original sub-construct within "beliefs" including beliefs about how people learn, beliefs about lesson design, beliefs about the teaching/learning environment, and beliefs about the nature of STEM. None of the categories maintained a coefficient alpha within the minimally acceptable level. Results of the coefficient alpha analysis are found in Table 4.21

Table 4.21

Coefficient Alpha for Student Sub-constructs

Student Beliefs	**Alpha**	**Items Removed**
How people learn	.231	2.1, 2.8
Lesson Design	.082	1.8
Environment	.328	None
NOS	.511	2.6, 1.6

**Indicates an alpha level above the minimally acceptable range*

Exploratory factor analysis could not be run with the student items due to the small sample size (N=53) (Hogarty et al., 2005; McCallum et al., 1999), so items within the student survey were placed in the categories determined by the exploratory factor analysis run with the adult items. Identical items between surveys were placed in the categories determined by the factor analysis, and items unique to the student survey were placed in the beliefs about student activities in STEM courses if the items were focused on the student. Items were placed in beliefs about curriculum/lesson design if the items were focused on the curriculum or lessons. Table 4.22 shows items within each category of beliefs for analysis of coefficient alpha using the revised categories of beliefs. The results of the reliability analysis using coefficient alpha of the student group after the reorganization of items into two categories: beliefs about student activities in STEM courses (.578), and beliefs about curriculum/lesson design (.487). Cronbach's alpha analysis results can be found in Table 4.23. Items identifying student beliefs about curriculum and lesson design were dropped due to the low alpha value; however, items regarding student beliefs about student activities were retained in spite of the low alpha value. Student beliefs about what students are doing in the classroom is a valuable piece of the culture of a school and can explain how students view the learning experience; therefore, the items were retained.

Table 4.22

Reorganized Items for Student Beliefs

Item Number	**Item**
Student actions within STEM courses	
SB2.8	Students should build their knowledge upon things they have learned in the past.
SB2.7	Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.
SB2.3	In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.
SB2.5	My counselors encourage me to take advanced STEM courses that might be difficult for me.
SB1.5	In the past, I have avoided signing up for a difficult STEM course because my peers told me not to.
Curriculum/lesson design	
SB1.1	There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.
SB1.9	The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.
SB1.2	During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.
SB1.8	Learning should be an orderly process, where students are presented material in a sequence to be remembered.
SB1.3	During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an

	experiment or solving a problem.
SB1.7	Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.
SB1.6	Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'
SB2.4	When someone makes a claim that something is true, they must present evidence to support their claim.

Table 4.23

Coefficient Alpha for Student Reorganized Sub-constructs

Student Beliefs	Alpha	Items Removed
Beliefs about student activities in STEM courses	.578	1.5, 2.5,2.8
Beliefs about curriculum/lesson design	.487	1.2, 1.3

**Indicates an alpha level above the minimally acceptable range*

Items within the *values* domain were identical for all four groups of stakeholders: parents, students, school leaders, and teachers. Cronbach's alpha was run for each group of stakeholders for *values* about STEM Education. All four groups of stakeholders favored removing item 1.1, so it was removed from all surveys. Results of the reliability analysis for all four groups of stakeholders can be found in Table 4.24.

Table 4.24

Coefficient Alpha for Values of STEM Education

Stakeholder Group	Alpha	Items Removed
Parents	.775*	1.1
Students	.748*	1.1
Teachers	.810*	1.1
School Leadership	.779*	1.1

**Indicates an alpha level above the minimally acceptable range*

For items within the *resources* domain, Cronbach's alpha was run for each group of stakeholders regarding their school's access to resources. Results of the reliability analysis for all four groups of stakeholders can be found in Table 4.25. Items under the *resources* domain for school leadership were dropped due to the low coefficient alpha, and items within the parent resources section were retained because the alpha was found to be in the “very good” range. Items within the teacher resources section had an alpha value that was too low to retain; however, items 1.1, 1.6, 1.7, 1.8 and 1.9 were retained because these items are the only items within the study that allowed for teachers’ perspective on what resources were available to them. Within the student resources section, items 1.1 and 1.2 were retained because they provided a student’s perspective of how large class sizes affect student learning. This is a key identifier of the culture of the school regarding education in science and mathematics.

Table 4.25

Coefficient Alpha for Resources in STEM Education

Stakeholder Group	Alpha	Items Removed
Parents	.801*	1.2, 1.5, 1.6
Students	.606	1.5
Teachers	.607	1.3, 1.5, 1.6, 1.7, 1.8
School Leadership	.638	1.1, 1.2, 1.3, 1.9

**Indicates an alpha level above the minimally acceptable range*

For items within the *challenges* domain, Cronbach’s alpha was run for each group of stakeholders regarding their school’s access to resources. Results of the reliability analysis for all four groups of stakeholders can be found in Table 4.26. These items were retained for both teachers and school leadership because the coefficient alpha falls within the “very good” range.

Table 4.26

Coefficient Alpha for Challenges in STEM Education

Stakeholder Group	Alpha	Items Removed
Parents	N/A	N/A
Students	N/A	N/A
Teachers	.870*	none

School Leadership	.841*	none

**Indicates an alpha level above the minimally acceptable range*

For items within the *challenges* domain, Cronbach's alpha was run for each group of stakeholders regarding their school's access to resources. Results of the reliability analysis for all four groups of stakeholders can be found in Table 4.27. Items within the teacher practices section were dropped due to an unacceptable alpha value, while items within the student and school leadership practice sections were retained.

Table 4.27

Coefficient Alpha for Practices in STEM Education

Stakeholder Group	Alpha	Items Removed
Parents	N/A	N/A
Students	.783*	1.4, 1.6, 1.8
Teachers	.579	1.2
School Leadership	.802*	1.3

**Indicates an alpha level above the minimally acceptable range*

All retained items were placed into an online survey platform as one large survey. Participants would begin the survey by identifying which school they were associated with, then identifying which role they served within the school: student, parent, teacher, or administrator/counselor. Once the participants identified which stakeholder group they belonged in, the survey would give them the appropriate questions and data collected.

Phase 4: Overall Construct Validity

Once the STEM-CAT had been determined to be reliable, it was used to determine the validity of the School STEM Culture construct. Eight schools elected to participate in the overall construct validity study. Each school selected a large group of seniors to participate in the survey requesting information about their plans after high school to determine the percentage of students intending to pursue STEM fields upon graduation. Schools were asked to survey the entire faculty including administrators and counselors, and a sample of 50 parents 50 students from across grade levels were invited to participate. Table 4.28 shows the number of participants from each stakeholder group from each school.

Table 4.28

Number of Participants for Each School by Stakeholder Group

School	Senior Survey Completed	Parents	Teachers	School leadership	Students	Total Participants
Evans High School	76	62	29	9	53	153
Williams High School	39	17	23	4	36	80
Fisk High School	366	27	32	8	173	240
Rice High School	60	6	24	2	166	198
Varitek High School	60	40	41	8	79	168
Boggs High School	57	5	23	2	64	94
Ortiz High School	107	39	39	6	66	150
Martinez High School	55	28	27	3	55	113

Percentage of students pursuing STEM fields. The percentage of students pursuing STEM fields for each school was determined by surveying a sample of seniors by asking them their plans after high school. The first questions asked if the student intended to attend a 2/4 year institution, enter the military, or enter the job force upon graduation. Students were then asked to classify their intended major or job field according to 16 career clusters as defined by the South Carolina Education and Economic Development Act as listed below:

- Agriculture, Food, and Natural Resources
- Architecture and Construction
- Arts, Audio-Video Technology & Communications
- Business, Management & Administration
- Education and Training
- Finance
- Government and Public Administration
- Health Science
- Hospitality and Tourism
- Human Services
- Information Technology
- Law, Public Safety and Corrections
- Manufacturing
- Marketing, Sales and Service
- Science, Technology, Engineering and Mathematics
- Transportation, Distribution and Logistics

Students were then given the opportunity to complete an open-ended question identifying the field they were most likely to enter upon graduation. Although some of the career clusters are likely to be STEM related, some fields are not as obvious. Allowing students the opportunity to complete an open-ended question about their field of choice provided an opportunity to be more detailed in the selection of which students were pursuing STEM fields. For example, a student choosing Law, Public Safety and Corrections is not clearly pursuing a STEM field; however, if that student identified that she intended to pursue the field of forensics, this put her into the STEM category. After collecting data from each school, each student response was identified as being a STEM field or not, and the percentage of responses pursuing a STEM field was calculated. Results for each school can be found in Table 4.29, with a sample individual response table found in Appendix C.

Table 4.29

Percentage of Students Pursuing STEM Fields

School Name	Percentage of Students Pursuing

	STEM Fields
Rice High School	64.3%
Fisk High School	45.6%
Evans High School	52.6%
Varitek High School	55.4%
Boggs High School	51.7%
Williams High School	55.3%
Ortiz High School	57.8%
Martinez High School	52.7%

STEM-CAT Results. Data were collected using Likert scale items regarding the five sub-groups of school culture. Results are reported using Positive Response Rate, which is the percentage of responses that favored strong STEM education culture, either all responses of "agree" and "strongly agree," or for negatively coded items all responses of "disagree" and "strongly disagree." The Positive Response Rate (PRR) indicates the percentage of responders whose responses indicate a favorable reflection of STEM culture according to the five sub-constructs identified.

Results of stakeholder analysis can be found in separate tables in Appendices D-K. Throughout the analysis of stakeholder responses, yellow cells indicated the highest percentage of responses for each particular group for each item. Red cells indicated a Positive Response Rate of less than 60% for that item, while green cells indicated a Positive Response Rate higher than 90%. Items that were negatively coded were highlighted in orange, and positive responses were considered a response of "strongly disagree" or "disagree." Positive response rates were calculated by taking the total responses that favored strong STEM education divided by total responses.

Rice High School. Data for the following report were collected at Rice High School in the spring of 2015. Data were collected from four separate stakeholder groups:

- 6 parents were recruited to participate through a school-wide email list

- 112 students were randomly selected through homerooms to participate
- 21 teachers of all core courses participated
- 1 member of school leadership including administrators and counselors

A summary of positive response rate for Rice High School can be found in Table 4.30. Results for each stakeholder group broken down by question, including percentage of each response and PRR, can be found in Appendix D.

Table 4.30

Summary Table of Positive Response Rates for Rice High School

Parent Beliefs- Positive Response Rate	61.1
Parent Values- Positive Response Rate	90.0
Parent Resources- Positive Response Rate	66.7
Overall Parent Positive Response Rate	72.6
Student Beliefs Positive Response Rate	72.1
Student Values Positive Response Rate	75.5
Student Resources Positive Response Rate	56.8
Student Practices Positive Response Rate	44.5
Overall Student Positive Response Rate	60.4
Teacher Beliefs Positive Response Rate	69.9
Teacher Values Positive Response Rate	84.0
Teacher Resources Positive Response Rate	43.8
Teacher Challenges Positive Response Rate	34.2
Overall Teacher Positive Response Rate	61.3
School Leadership Beliefs Positive Response Rate	87.5
School Leadership Values Positive Response Rate	100.0
School Leadership Practices Positive Response Rate	100.0
School Leadership Challenges Positive Response Rate	100.0
Overall School Leadership Positive Response Rate	95.2
School-wide Positive Response Rate for All Stakeholders	61.1

Graphs comparing individual item responses for different stakeholder groups are not presented for Rice High School due to the small sample size of parents (n=6) and school leadership (n=1). This is a large limitation for data from this school, as the large number of student responses in comparison to the small number of parent responses skewed the data in favor of student opinion. This issue will be addressed in the final analysis.

Fisk High School. Data were collected at Fisk High School in the spring of 2015. Data were collected from four separate stakeholder groups:

- 28 parents were recruited to participate through a school-wide email list
- 195 students were randomly selected through homerooms to participate
- 37 teachers of all core courses participated
- 8 members of school leadership including administrators and counselors

A summary of positive response rate for Fisk High School can be found in Table 4.31. Results for each stakeholder group broken down by question, including percentage of each response and PRR can be found in Appendix E.

Table 4.31

Summary Table of Positive Response Rate for Fisk High School

Parent Beliefs- Positive Response Rate	91.7
Parent Values- Positive Response Rate	81.4
Parent Resources- Positive Response Rate	76.2
Overall Parent Positive Response Rate	84.7
Student Beliefs Positive Response Rate	61.8
Student Values Positive Response Rate	71.0
Student Resources Positive Response Rate	46.0
Student Practices Positive Response Rate	40.5
Overall Student Positive Response Rate	53.9
Teacher Beliefs Positive Response Rate	76.0
Teacher Values Positive Response Rate	91.4
Teacher Resources Positive Response Rate	37.2
Teacher Challenges Positive Response Rate	40.0
Overall Teacher Positive Response Rate	66.4
School Leadership Beliefs Positive Response Rate	73.4
School Leadership Values Positive Response Rate	77.1

School Leadership Practices Positive Response Rate	91.7
School Leadership Challenges Positive Response Rate	41.7
Overall School Leadership Positive Response Rate	68.0
School-wide Positive Response Rate for All Stakeholders	58.7

An analysis of common items between stakeholder groups for Fisk High School shows similar perceptions, with no discrepancies between stakeholder groups. This indicates that for the issues that common items were present, the stakeholders at this school have little variance between them. Graphs of these common item responses can be found in Appendix C.

Evans High School. Data were collected at Evans High School in the Spring of 2014. Data was collected from four separate stakeholder groups:

- 55 parents were recruited to participate through a school-wide email list
- 53 students were randomly selected through homerooms to participate
- 23 teachers of all core courses participated
- 9 members of school leadership including administrators and counselors

A summary of positive response rate for Evans High School can be found in Table 4.32. Results for each stakeholder group are divided by question, including percentage of each response. PRR can be found in Appendix F.

Table 4.32

Summary Table of Positive Response Rate for Evans High School

Parent Beliefs- Positive Response Rate	90.2
Parent Values- Positive Response Rate	87.6
Parent Resources- Positive Response Rate	43.2
Overall Parent Positive Response Rate	**79.2**
Student Beliefs Positive Response Rate	72.3
Student Values Positive Response Rate	83.3

Student Resources Positive Response Rate	61.2
Student Practices Positive Response Rate	62.2
Overall Student Positive Response Rate	**69.6**
Teacher Beliefs Positive Response Rate	74.5
Teacher Values Positive Response Rate	89.0
Teacher Resources Positive Response Rate	37.1
Teacher Challenges Positive Response Rate	71.8
Overall Teacher Positive Response Rate	**71.1**
School Leadership Beliefs Positive Response Rate	65.3
School Leadership Values Positive Response Rate	95.0
School Leadership Practices Positive Response Rate	87.5
School Leadership Challenges Positive Response Rate	64.6
Overall School Leadership Positive Response Rate	**73.9**
School-wide Positive Response Rate for All Stakeholders	**72.8**

Data for common items between stakeholder groups are presented in Figures 4.1 and 4.2 to compare the perception of stakeholder groups. Although perceptions by different groups of stakeholders are often similar, some differences can be seen in the graphs. In Figure 4.1, note that teachers tend to disagree with the statement that "learning should be an orderly process, where material should be presented in a sequence to remember," while school leadership tend to agree with the statement. The intent of this question was to determine if the stakeholder believes that students should construct content in their own way rather than construct the content in a particular sequence focusing on memorization. These results indicate that school leadership might lean towards teacher constructed knowledge rather than student constructed knowledge. Figure 4.2 indicates that teachers in general disagree with the statement that students should learn to work independently to avoid relying on someone else to do their work for them while school leadership remain mainly neutral on the statement. This item was intended to determine if stakeholders believe that learning should be collaborative to encourage discussion and the exchange of ideas which is an indicator of strong STEM education (Sampson, 2013.)

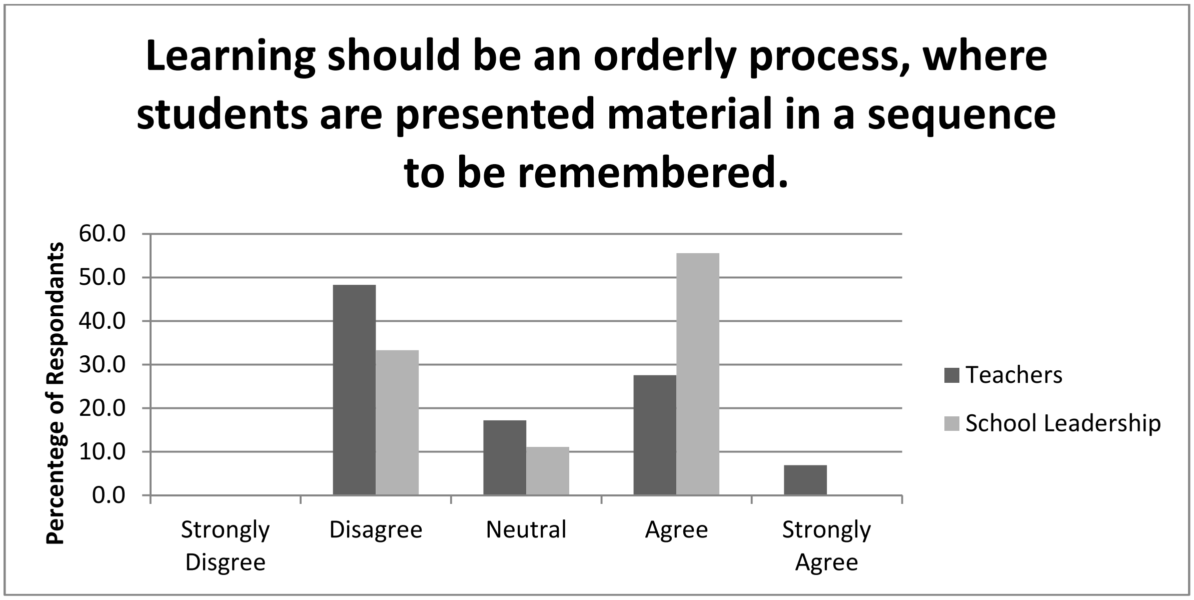

Figure 4.1. Comparison 1 of item responses between teachers and school leadership for Evans High School.

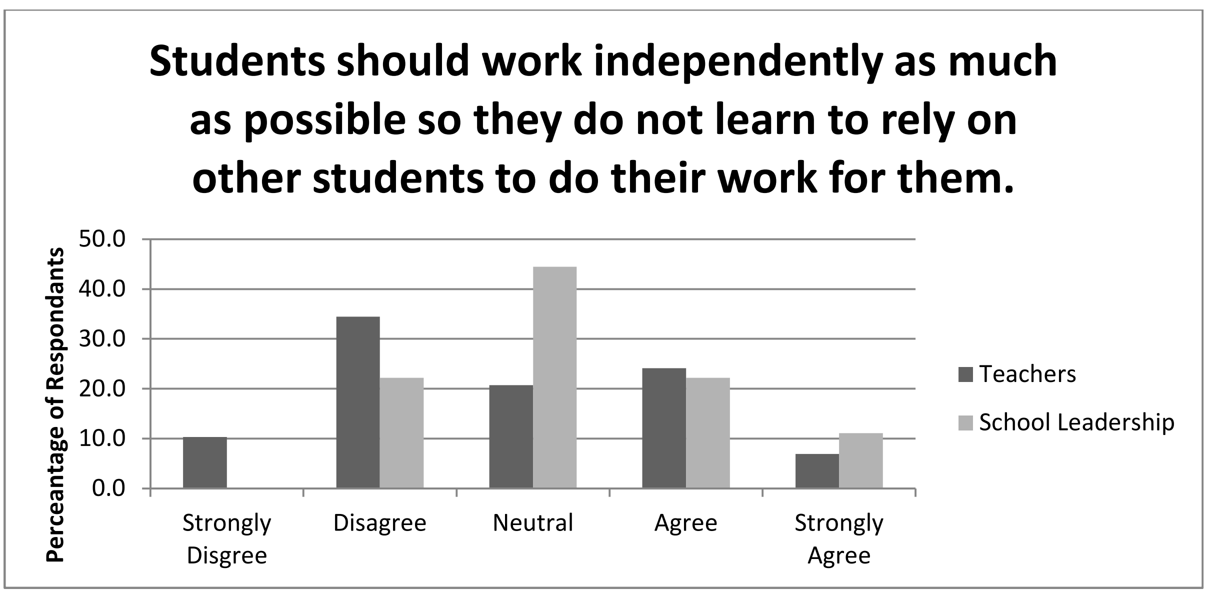

Figure 4.2. Comparison 2 of item responses between teachers and school leadership for Evans High School.

Varitek High School. Data for the following report were collected at Varitek High School in the spring of 2015. Data were collected from four separate stakeholder groups:

- 40 parents were recruited to participate through a school-wide email list
- 79 students were randomly selected through homerooms to participate
- 41 teachers of all core courses participated
- 8 members of school leadership including administrators and counselors

A summary of positive response rate for Varitek High School can be found in Table 4.33. Results for each stakeholder group are divided by question, including percentage of each response, and PRR can be found in Appendix G.

Table 4.33

Summary Table of Positive Response Rate for Varitek High School

Parent Beliefs- Positive Response Rate	87.6
Parent Values- Positive Response Rate	85.1
Parent Resources- Positive Response Rate	71.4
Overall Parent Positive Response Rate	83.2
Student Beliefs Positive Response Rate	65.4
Student Values Positive Response Rate	67.9
Student Resources Positive Response Rate	48.2
Student Practices Positive Response Rate	38.7
Overall Student Positive Response Rate	53.6
Teacher Beliefs Positive Response Rate	76.5
Teacher Values Positive Response Rate	92.1
Teacher Resources Positive Response Rate	45.5
Teacher Challenges Positive Response Rate	72.8
Overall Teacher Positive Response Rate	74.3
School Leadership Beliefs Positive Response Rate	79.2
School Leadership Values Positive Response Rate	100.0
School Leadership Practices Positive Response Rate	66.7
School Leadership Challenges Positive Response Rate	61.1
Overall School Leadership Positive Response Rate	77.8

School-wide Positive Response Rate for All Stakeholders	66.0

Data for common items between stakeholder groups are presented in Figure 4.3 to compare the perception of stakeholder groups. Although perceptions by different groups of stakeholders are often similar, a difference can be seen in this figure. In Figure 4.3, note that all adult stakeholders seem to disagree with the statement that some students do not have the ability to learn science and mathematics, no matter how hard they try. Contrary to this, the majority of students seem to agree with this statement. The intent of this question was to determine if the stakeholder believed that there were some students who just did not possess the ability to learn high level science and mathematics, and it seems at this school that some students believed this to be the truth. It is a positive that the majority of adult stakeholders seemed to disagree with this statement.

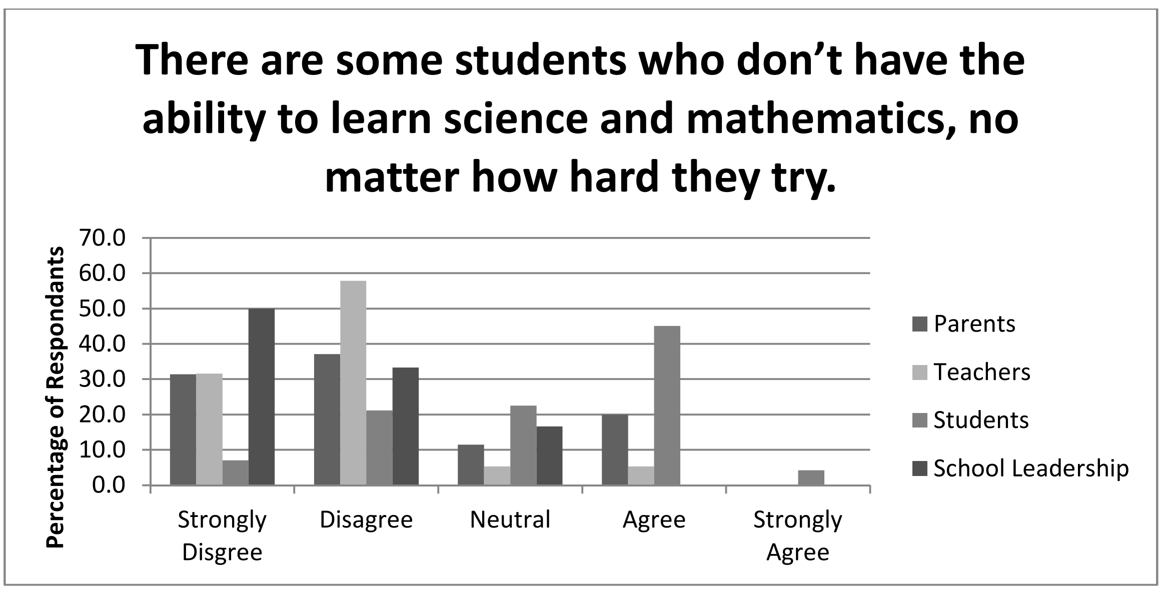

Figure 4.3. Comparison of item responses between parents, teachers, students and school leadership for Varitek High School.

Boggs High School. Data for the following report were collected at Boggs High School in the spring of 2015. Data were collected from four separate stakeholder groups:

- 5 parents were recruited to participate through a school-wide email list
- 48 students were randomly selected through homerooms to participate
- 23 teachers of all core courses participated
- 2 members of school leadership including administrators and counselors

A summary of positive response rate for Boggs High School can be found in Table 4.33. Results for each stakeholder group are divided by question, including percentage of each response, and PRR can be found in Appendix H.

Table 4.33

Summary Table of Positive Response Rate for Boggs High School

Parent Beliefs- Positive Response Rate	96.7
Parent Values- Positive Response Rate	100.0
Parent Resources- Positive Response Rate	66.7
Overall Parent Positive Response Rate	91.4
Student Beliefs Positive Response Rate	60.9
Student Values Positive Response Rate	71.6
Student Resources Positive Response Rate	32.0
Student Practices Positive Response Rate	41.5
Overall Student Positive Response Rate	52.8
Teacher Beliefs Positive Response Rate	71.9
Teacher Values Positive Response Rate	91.8
Teacher Resources Positive Response Rate	29.5
Teacher Challenges Positive Response Rate	33.3
Overall Teacher Positive Response Rate	60.8
School Leadership Beliefs Positive Response Rate	87.5
School Leadership Values Positive Response Rate	90.0
School Leadership Practices Positive Response Rate	75.0
School Leadership Challenges Positive Response Rate	66.7
Overall School Leadership Positive Response Rate	81.0
School-wide Positive Response Rate for All Stakeholders	57.8

An analysis of common items between stakeholder groups for Boggs High School shows similar perceptions with no discrepancies between stakeholder groups. This indicates that for the issues that common items were present, the stakeholders at this school had little variance between them. Graphs of these common item responses can be found in Appendix C.

Williams High School. Data for the following report were collected at Williams High School in the spring of 2015. Data were collected from four separate stakeholder groups:

- 17 parents were recruited to participate through a school-wide email list
- 36 students were randomly selected through homerooms to participate
- 23 teachers of all core courses participated
- 4 members of school leadership including administrators and counselors

A summary of positive response rate for Williams High School can be found in Table 4.34. Results for each stakeholder group are divided by question, including percentage of each response, and PRR can be found in Appendix I.

Table 4.34

Summary Table of Positive Response Rate for Williams High School

Parent Beliefs- Positive Response Rate	89.1
Parent Values- Positive Response Rate	100.0
Parent Resources- Positive Response Rate	41.2
Overall Parent Positive Response Rate	82.7
Student Beliefs Positive Response Rate	72.1
Student Values Positive Response Rate	77.9
Student Resources Positive Response Rate	63.8
Student Practices Positive Response Rate	37.5
Overall Student Positive Response Rate	58.1

Teacher Beliefs Positive Response Rate	70.6
Teacher Values Positive Response Rate	90.9
Teacher Resources Positive Response Rate	36.4
Teacher Challenges Positive Response Rate	32.6
Overall Teacher Positive Response Rate	59.7
School Leadership Beliefs Positive Response Rate	63.2
School Leadership Values Positive Response Rate	100.0
School Leadership Practices Positive Response Rate	50.0
School Leadership Challenges Positive Response Rate	50.0
Overall School Leadership Positive Response Rate	66.7
School-wide Positive Response Rate for All Stakeholders	62.8

Data for common items between stakeholder groups are presented in Figures 4.4 - 4.6 to compare the perception of stakeholder groups. Teachers for this school seemed to be split regarding these three items. Each item focused on the issue of whether students should construct knowledge in their brain, or if the knowledge construction should be teacher-centered. A teacher-centered model has the student focus on sequences and order rather than the overall process, with a constructivist view considering science as messy and having several means to an end. For each of these items, over 20% of teachers answered on both sides of neutral, indicating that the teachers fell into two categories at this school with one group believing in constructivist ideas and the other group believing in teacher-centered learning. When analyzing these items for teachers of specific courses, the science teachers at this school were split with slightly more teachers leaning towards constructivist ideas (4 out of 8, with 2 neutral responses), while the mathematics teachers who responded were unanimous (5 of 5 responses) in their responses favoring teacher-centered instruction.

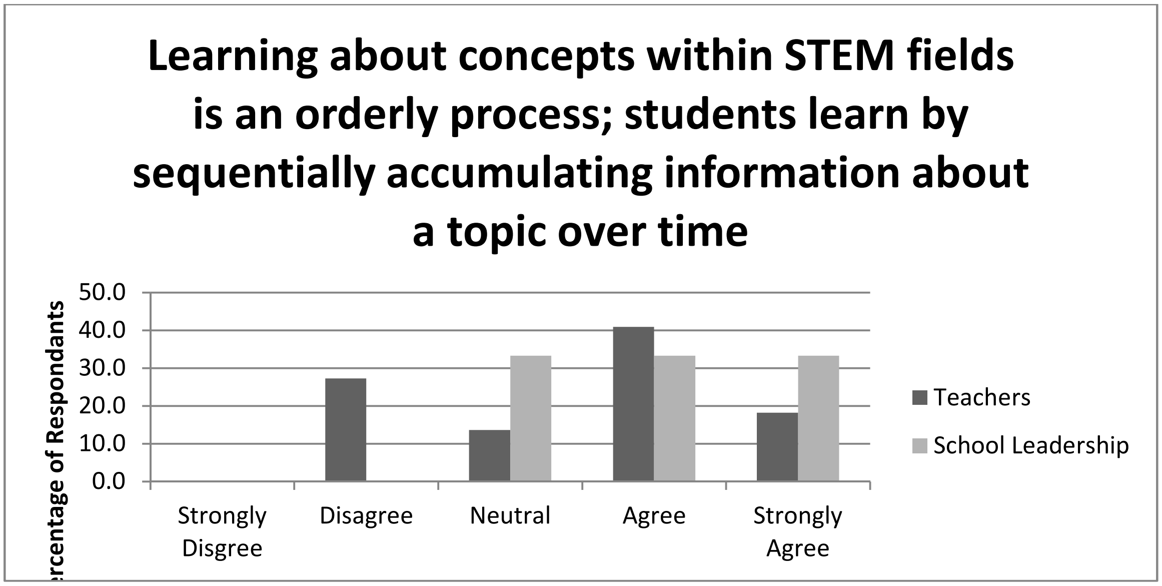

Figure 4.4. *Comparison 1 of item responses between teachers and school leadership for Williams High School.*

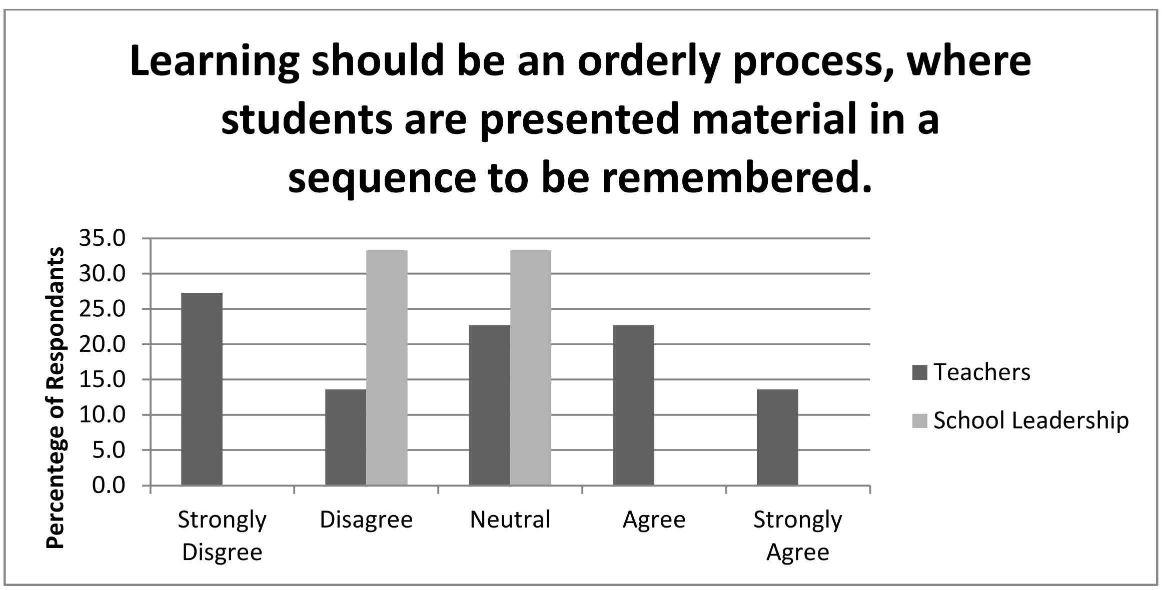

Figure 4.5. *Comparison 2 of item responses between teachers and school leadership for Williams High School.*

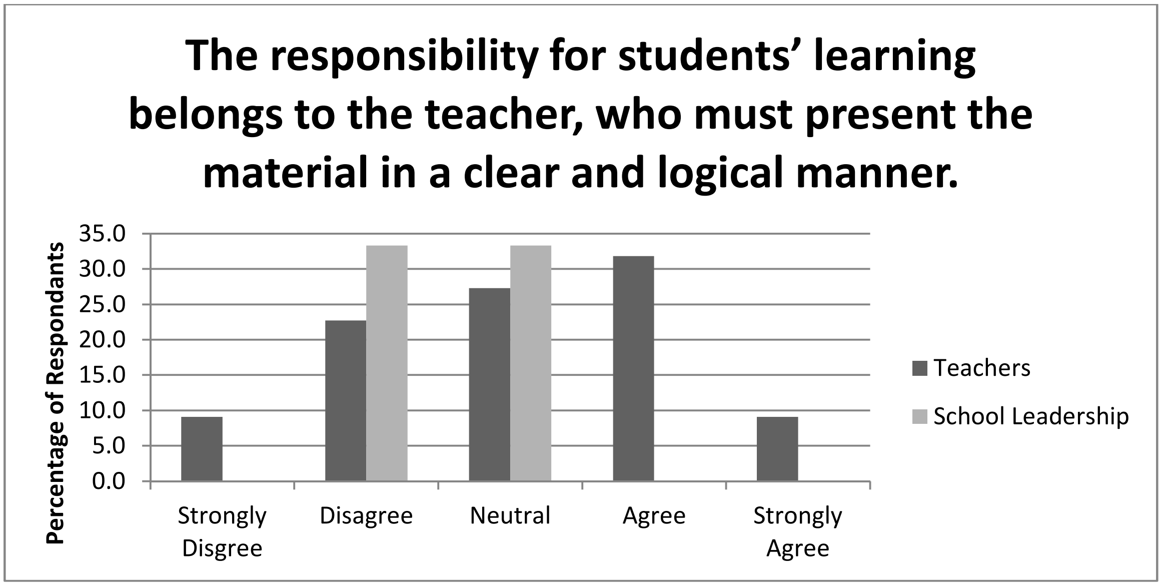

Figure 4.6.. Comparison 3 of item responses between teachers and school leadership for Williams High School.

Ortiz High School. Data for the following report were collected at Ortiz High School in the spring of 2015. Data were collected from four separate stakeholder groups:

- 39 parents were recruited to participate through a school-wide email list
- 66 students were randomly selected through homerooms to participate
- 39 teachers of all core courses participated
- 8 members of school leadership including administrators and counselors

A summary of positive response rate for Ortiz High School can be found in Table 4.36. Results for each stakeholder group are divided by question, including percentage of each response, and PRR can be found in Appendix J.

Table 4.36

Summary Table of Positive Response Rate for Ortiz High School

Parent Beliefs- Positive Response Rate	81.4
Parent Values- Positive Response Rate	90.6
Parent Resources- Positive Response Rate	63.7

Overall Parent Positive Response Rate	80.9
Student Beliefs Positive Response Rate	67.2
Student Values Positive Response Rate	73.2
Student Resources Positive Response Rate	57.4
Student Practices Positive Response Rate	44.0
Overall Student Positive Response Rate	58.2
Teacher Beliefs Positive Response Rate	75.0
Teacher Values Positive Response Rate	88.2
Teacher Resources Positive Response Rate	34.9
Teacher Challenges Positive Response Rate	44.8
Overall Teacher Positive Response Rate	64.0
School Leadership Beliefs Positive Response Rate	66.0
School Leadership Values Positive Response Rate	96.7
School Leadership Practices Positive Response Rate	66.7
School Leadership Challenges Positive Response Rate	60.0
Overall School Leadership Positive Response Rate	71.8
School-wide Positive Response Rate for All Stakeholders	64.9

An analysis of common items between stakeholder groups for Ortiz High School shows similar perceptions, with no discrepancies between stakeholder groups. This indicates that for the issues where common items were present, the stakeholders at this school had little variance between them. Graphs of these common item responses can be found in Appendix C.

Martinez High School. Data for the following report were collected at Martinez High School in the spring of 2015. Data were collected from four separate stakeholder groups:

- 28 parents were recruited to participate through a school-wide email list
- 55 students were randomly selected through homerooms to participate
- 27 teachers of all core courses participated
- 3 members of school leadership including administrators and counselors

A summary of positive response rate for Martinez High School can be found in Table 4.37. Results for each stakeholder group are divided by question, including percentage of each response, and PRR can be found in Appendix K.

Table 4.37

Summary Table of Positive Response Rate for Martinez High School

Parent Beliefs- Positive Response Rate	84.6
Parent Values- Positive Response Rate	89.9
Parent Resources- Positive Response Rate	46.2
Overall Parent Positive Response Rate	78.2
Student Beliefs Positive Response Rate	73.7
Student Values Positive Response Rate	76.3
Student Resources Positive Response Rate	39.7
Student Practices Positive Response Rate	34.2
Overall Student Positive Response Rate	54.9
Teacher Beliefs Positive Response Rate	68.3
Teacher Values Positive Response Rate	90.0
Teacher Resources Positive Response Rate	26.9
Teacher Challenges Positive Response Rate	32.7
Overall Teacher Positive Response Rate	58.2
School Leadership Beliefs Positive Response Rate	83.3
School Leadership Values Positive Response Rate	100.0
School Leadership Practices Positive Response Rate	66.7
School Leadership Challenges Positive Response Rate	44.4
Overall School Leadership Positive Response Rate	74.6
School-wide Positive Response Rate for All Stakeholders	61.2

An analysis of common items between stakeholder groups for Martinez High School show similar perceptions, with no discrepancies between stakeholder groups. This indicates that for the issues where common items were present, the stakeholders at this school had little variance between them. Graphs of these common item responses can be found in Appendix C.

Hypothesis Test Analysis

Item response equality method. The following hypothesis test was used to support construct validity for School STEM Culture and is stated as follows:

H_o: There is no correlation between the Total School STEM Culture Survey Positive Response Rate and the Percentage of Students self-reporting that they intend to pursue STEM fields.

H_a: There is a correlation between the School STEM Culture Survey Positive Response Rate and the Percentage of Students self-reporting that they intend to pursue STEM fields.

Figure 4.7 is a scatterplot showing the Total Positive Response Rate (PRR) versus Percent of Seniors Pursuing STEM Fields. The data in the scatterplot suggests that five of the eight schools forming a linear pattern, with three schools that have a significant difference from the others. Due to the small sample size, these schools cannot be considered outliers, as the relationship may just as likely be that the other five schools are too similar to detect a relationship.

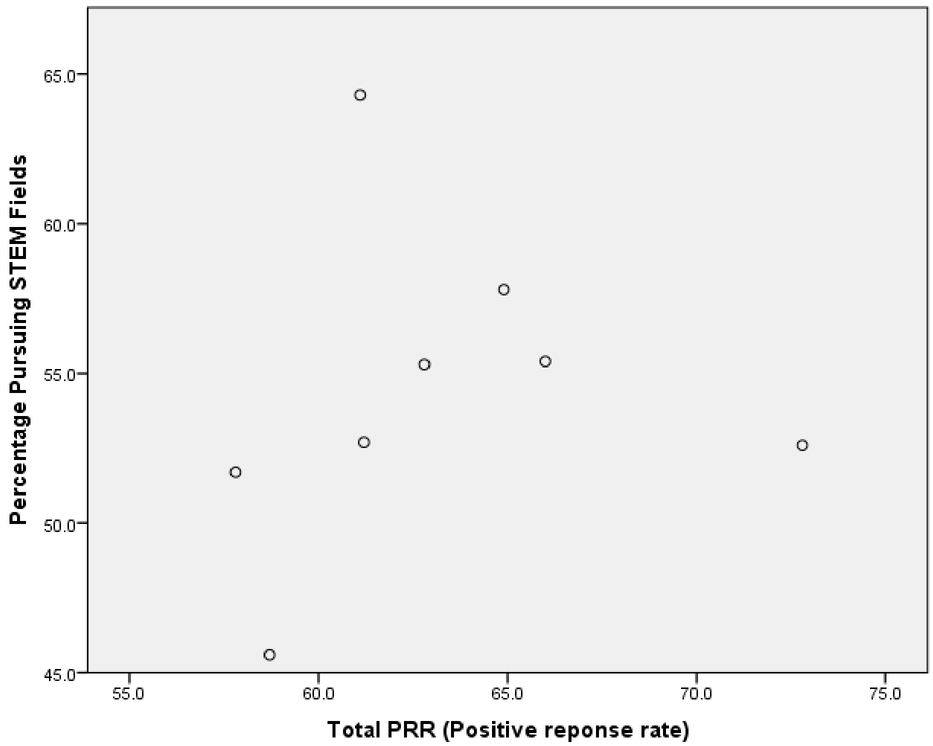

Figure 4.7. Scatterplot of total positive response rate vs. percentage of students pursuing STEM Fields.

The hypothesis was tested using Pearson's correlation coefficient (Hinkle,Wiersma, & Jurs, 2003). Table 4.38 shows no statistically significant correlation between Total PRR and Percentage of Students Pursuing STEM Fields, *r*(6)=.046, p=.457.

Table 4.38

Pearson's Correlation Coefficient for Total Positive Response Rate vs. Percentage of Students Pursuing STEM Fields

		Percentage Pursuing STEM Fields	Total PRR (Positive response rate)
Percentage Pursuing STEM Fields	Pearson Correlation	1	-0.046
	Sig. (1-tailed)		0.457
	N	8	8

Because of the small sample size, the three schools which do not follow the linear pattern shown in the scatterplot play a large role in making the results of a correlation insignificant. In analyzing these schools, two of the them (Boggs High School and Rice High School) had very small parent response rate with five and six parents responding, respectively. The other school, Evans High School, had a much larger number of parents respond to the survey than all other participating schools (n=62). Figure 4.8 is a scatterplot which shows the Total PRR versus Percentage of Students Pursuing STEM Fields for the remaining five schools.

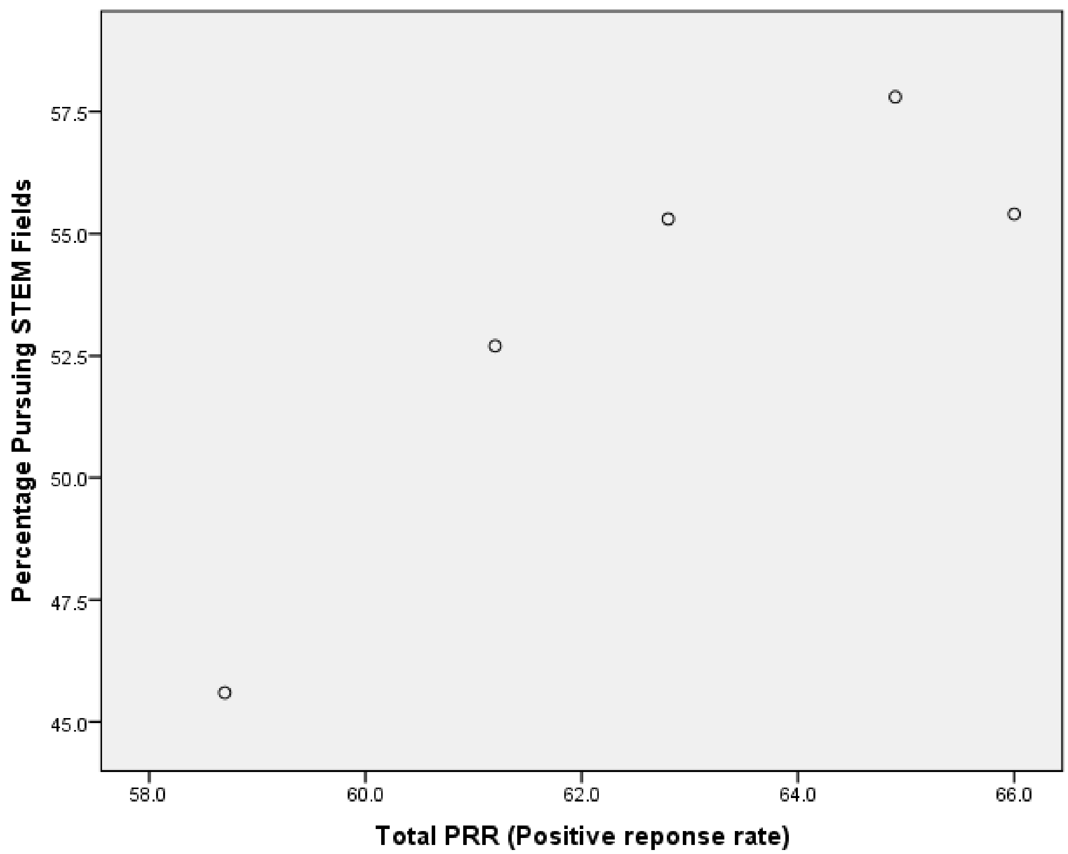

Figure 4.8. Scatterplot of total positive response rate vs. percentage of students pursuing STEM fields after removing Boggs, Fisk and Evans High Schools.

Table 4.39 shows a statistically significant correlation between Total PRR and Percentage of Students Pursuing STEM Fields, $r(3)=.957$, $p=.005$. Although a sample of five high schools is a very small sample to show correlational relationships, this strong correlation suggests the need for further research into this correlation as there may or may not be a trend. A bigger sample size with more comparable samples for each stakeholder might show more valid results.

Table 4.39

Pearson's Correlation Coefficient for Total Positive Response Rate vs. Percentage of Students Pursuing STEM Fields after Removing Evans, Boggs and Rice High Schools

		Percentage Pursuing STEM Fields	Total PRR (Positive response rate)
Percentage Pursuing STEM Fields	Pearson Correlation	1	0.957
	Sig. (1-tailed)		.005
	N	5	5

* Correlation is significant at the 0.05 level (2-tailed)

The original hypothesis was tested to see if Positive Response Rates for individual stakeholder groups would correlate better to the Percentage Pursuing STEM Fields using the Pearson Correlation Coefficient. Figure 4.9 is a scatterplot showing the Teachers' Positive Response Rate (PRR) versus Percent of Seniors Pursuing STEM Fields. The data in the scatterplot shows the possibility of an existing trend which may be supported with further data collection.

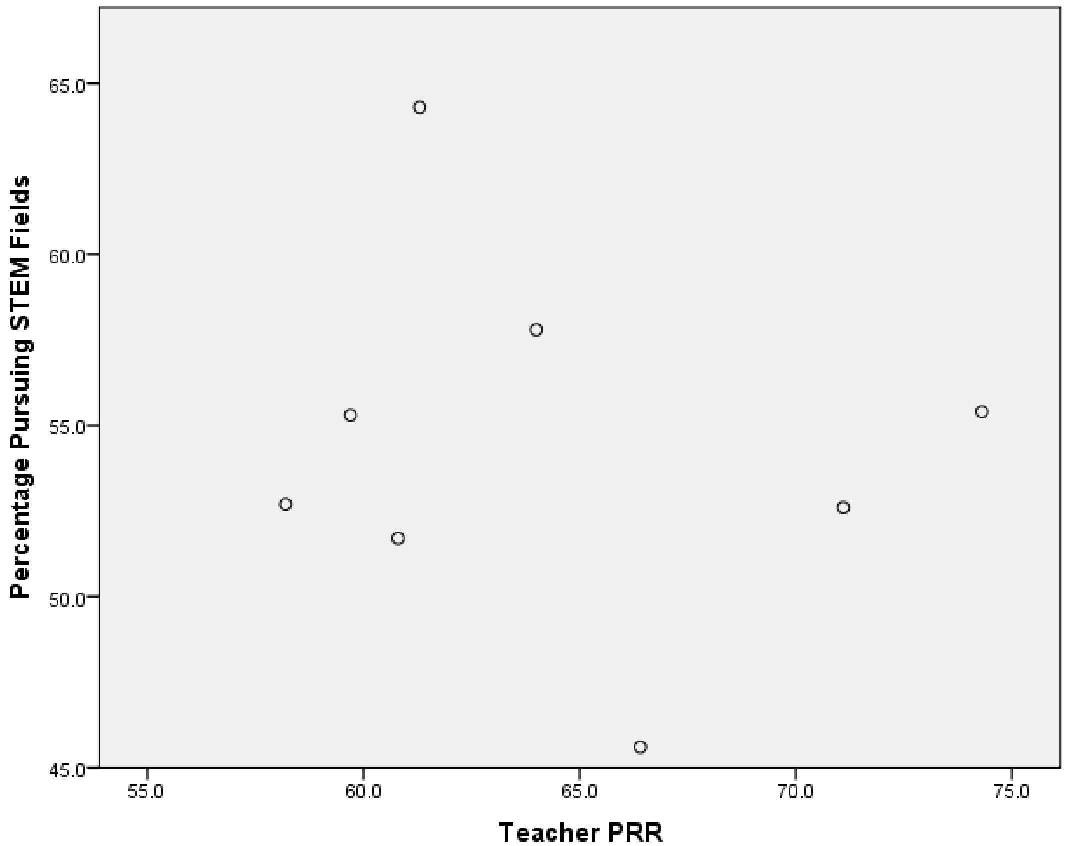

Figure 4.9. Scatterplot of teacher positive response rate vs. percentage of students pursuing STEM Fields.

The hypothesis was retested using Pearson's correlation coefficient (Hinkle, Wiersma, & Jurs, 2003) for Teachers' PRR versus Percentage of Students Pursuing STEM Fields. Table 4.40 shows no statistically significant correlation between Teacher PRR and Percentage of Students Pursuing STEM Fields, r(6)=-.237, p=.286.

Table 4.40

Pearson's Correlation Coefficient for Teachers' Positive Response Rate vs. Percentage of Students Pursuing STEM Fields after Removing Outlier Schools

		Percentage Pursuing STEM Fields	Teacher PRR
Percentage Pursuing STEM Fields	Pearson Correlation	1	-.237
	Sig. (1-tailed)		.286
	N	8	8

Figure 4.10 is a scatterplot showing the Parents' Positive Response Rate (PRR) versus Percent of Seniors Pursuing STEM Fields. The data in the scatterplot shows a cluster of six data points with two points seeming to be outliers.

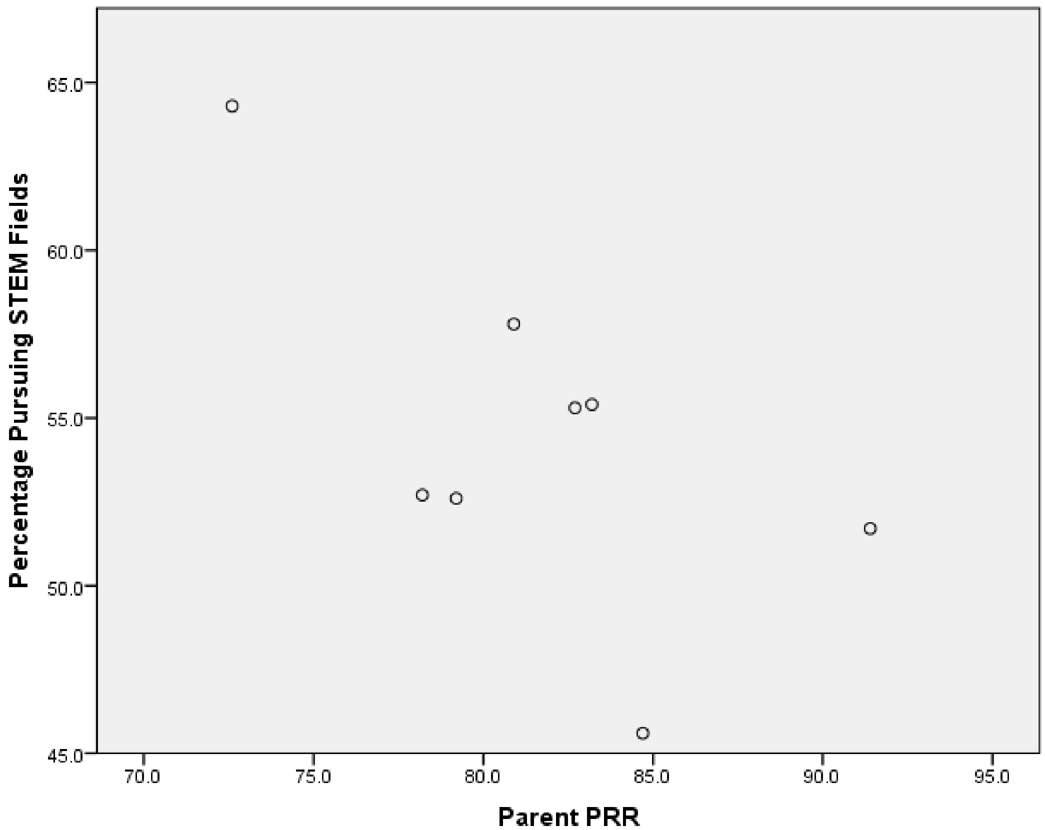

Figure 4.10. Scatterplot of parent positive response rate vs. percentage of students pursuing STEM fields.

The hypothesis was retested using Pearson's correlation coefficient for Parents' PRR versus Percentage of Students Pursuing STEM Fields. Table 4.41 shows no statistically significant correlation between Parent PRR and Percentage of Students Pursuing STEM Fields, $r(6)=-.646$, $p=.042$.

Table 4.41

Pearson's Correlation Coefficient for Parents' Positive Response Rate vs. Percentage of Students Pursuing STEM Fields after Removing Outlier Schools

		Percentage Pursuing STEM Fields	Teacher PRR
Percentage Pursuing STEM Fields	Pearson Correlation	1	-.646
	Sig. (1-tailed)		.042
	N	8	8

*Correlation is significant at the 0.05 level (1-tailed

Figure 4.11 is a scatterplot showing the Students' Positive Response Rate (PRR) versus Percent of Seniors Pursuing STEM Fields. The data in the scatterplot shows a cluster of six data points with two points seeming to be outliers.

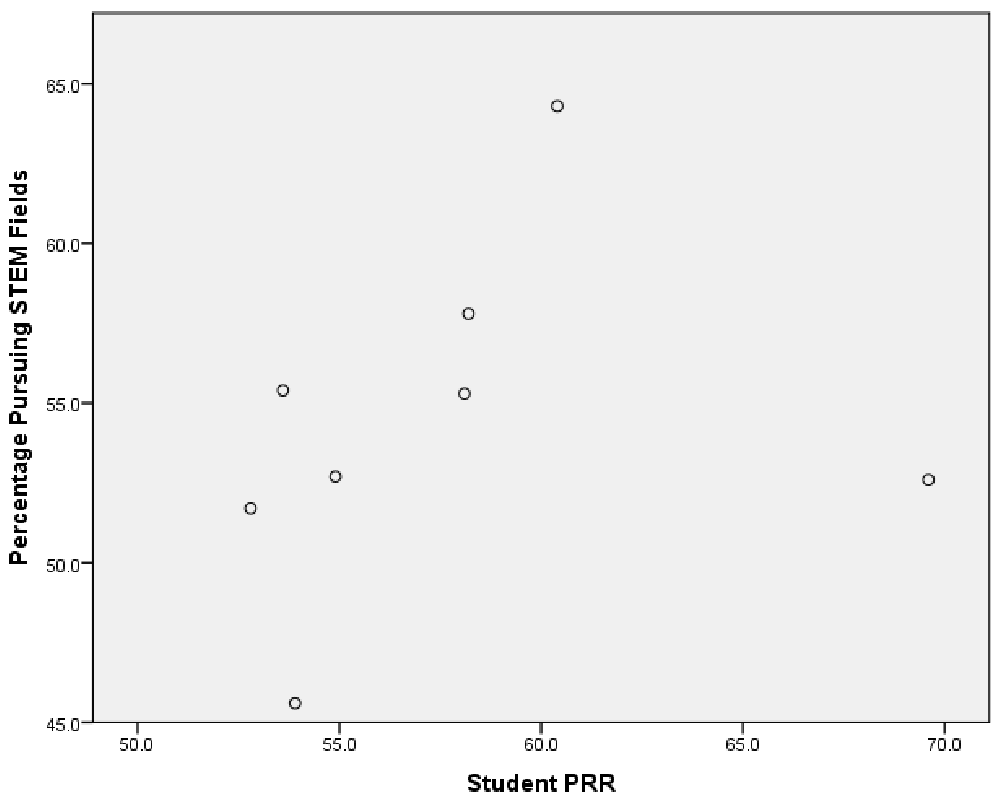

Figure 4.11. Scatterplot of student positive response rate vs. percentage of students pursuing STEM fields.

The hypothesis was retested using Pearson's correlation coefficient for Students' PRR versus Percentage of Students Pursuing STEM Fields. Table 4.42 shows no statistically significant correlation between Student PRR and Percentage of Students Pursuing STEM Fields, $r(6)=.064$, p=.440.

Table 4.42

Pearson's Correlation Coefficient for Students' Positive Response Rate vs. Percentage of Students Pursuing STEM Fields after Removing Outlier Schools

		Percentage Pursuing STEM Fields	Teacher PRR
Percentage Pursuing STEM Fields	Pearson Correlation	1	.064
	Sig. (2-tailed)		.440
	N	8	8

A correlation coefficient was not calculated for the School Leadership stakeholder group because several of the schools had less than three participants complete the survey, and the sample size was not large enough.

Stakeholder-domain equality method. In each of the previous hypothesis tests using the Item Response Equality Method, the voice of each individual respondent counted equally. Considering there were unequal numbers of participants in each stakeholder group, the Stakeholder-domain equality method was used that took the average PRR from the four groups of stakeholders from each school correlated to the Percent of Seniors Pursuing STEM Fields. Using the average PRR from all stakeholder groups would give each group an equal voice in defining the culture of the school rather than allow one group to overpower the others with a larger number of participants.

The same hypothesis test from the previous method was used to support construct validity for School STEM Culture and is stated as follows:

H_o: There is no correlation between the Total School STEM Culture Survey Positive Response Rate and the Percentage of Students self-reporting that they intend to pursue STEM fields.

H_a: There is a correlation between the School STEM Culture Survey Positive Response Rate and the Percentage of Students self-reporting that they intend to pursue STEM fields.

Figure 4.12 is a scatterplot showing the Average Positive Response Rate (PRR) versus Percent of Seniors Pursuing STEM Fields. The data in the scatterplot shows a cluster of six data points with two points seeming to be different in some way.

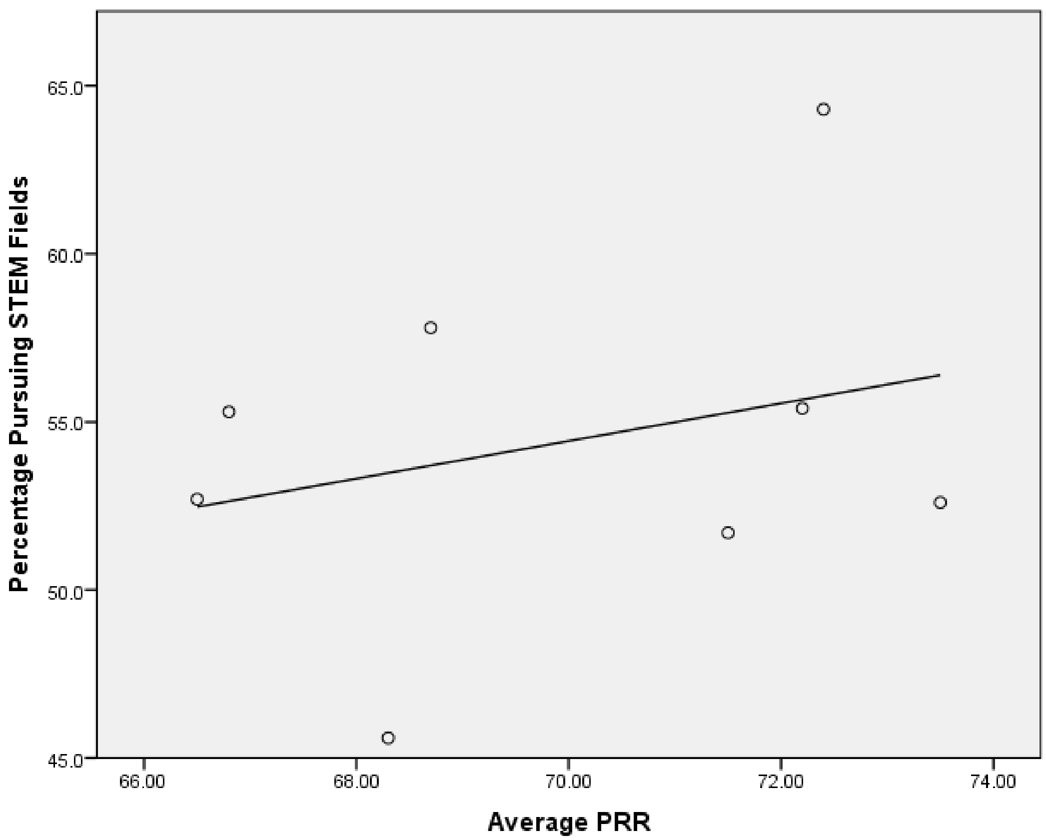

Figure 4.12. Scatterplot of average positive response rate vs. percentage of students pursuing STEM fields.

The hypothesis was retested using Pearson's correlation coefficient for Average PRR versus Percentage of Students Pursuing STEM Fields. Table 4.43 shows no statistically significant correlation between Average PRR and Percentage of Students Pursuing STEM Fields, $r(6)=.415$, $p=.154$.

Table 4.43

Pearson's Correlation Coefficient for Average Positive Response Rate vs. Percentage of Students Pursuing STEM Fields

		Percentage Pursuing STEM Fields	Teacher PRR
Percentage Pursuing STEM Fields	Pearson Correlation	1	.415
	Sig. (1-tailed)		.154
	N	8	8

Hypothesis 2. Hypothesis 2 is being used as a secondary support content validity for School STEM Culture and is stated as follows:

H_o: The positive response rates (PRR) for parents, students, teachers and school leadership do not add independent information in predicting the Percentage of Students self-reporting that they intend to pursue STEM fields.

H_a: The positive response rates (PRR) for parents, students, teachers and school leadership add independent information in predicting the Percentage of Students self-reporting that they intend to pursue STEM fields.

A stepwise multiple linear regressions analysis (Hinkle, Wiersma, & Jurs, 2003) was completed to test the hypothesis and see if the PRR for stakeholders combined would adequately predict the Percentage of Seniors Pursuing STEM Fields. The PRR for each stakeholder group was treated as a separate independent variable for this analysis. Upon analyzing the data using the stepwise multiple regression, none of the variables were included in the equation, and therefore, the data failed to reject the null hypothesis for both the Item Response Equality Method and the Stakeholder-Domain Equality Method.

CHAPTER FIVE: DISCUSSION

The purpose of this study was to determine if a culture aspect within a school community exists, termed School STEM Culture, which is defined as the beliefs, values, practices, resources, and challenges of the parents, teachers, students, and school leadership within a school community with regard to STEM education. The methods of this study were guided by the following objectives:

1. Design and validate an instrument that measures the construct of School STEM Culture, defined as the beliefs, values, practices, resources and challenges regarding STEM as reported by the students, administrators, parents, teachers and counselors in a particular school. 2. Correlate the results from the School STEM Culture Instrument with the percentage of self-reporting seniors pursuing STEM fields to link the STEM cultural aspect of a school with pursuance of STEM fields by graduates.

This study was completed to measure the level of a school's STEM Culture with the hopes that once the STEM Culture can be quantified, future research can be done to manipulate a school's STEM Culture to encourage more students to pursue STEM fields upon graduation, deepening the STEM workforce in the US over time.

Findings and Interpretations

This study was completed in four phases consisting of (a) an initial item design, (b) an expert review, (c) reliability testing, and (d) overall content validity. Through phases one through three, the STEM-CAT was found to be a valid, reliable measure of School STEM Culture as defined as the beliefs, values, practices, resources, and challenges of a school community with regard to STEM education as perceived by the parents, students, teachers, and school leadership. Validity was measured using face validity as determined by a focus group of five graduate students, and followed by a group of nine experts from across the STEM fields. Reliability was measured by internal consistency using exploratory factor analysis and Cronbach's Alpha. The original organization of items was created using the theoretical framework; however, after insignificant Cronbach's Alpha values were found for the beliefs domain, an exploratory factor analysis was used to categorize the items into beliefs about student activities in STEM courses and beliefs about lesson and curriculum design. After reorganization of the items into two categories within the beliefs domain, several stakeholder/sub-construct sections of items were deemed valid including parent beliefs about student activities, teacher beliefs about student activities, and school leadership beliefs about lesson and curriculum design. Other stakeholder/domain combinations that were determined to be valid were all stakeholder STEM values, parent perception of STEM resources, teachers' and school leadership's perception of challenges, and students' and school leadership's perception of practices in STEM education. Each of these validated stakeholder/domain combinations was added to the final version of the STEM-CAT and used for the content validity portion of the study.

The purpose of the STEM-CAT was to measure the School STEM Culture of a school community by gathering responses from stakeholders including parents, teachers, students, and school leadership. The responses of each stakeholder group were compiled to determine the Positive Response Rate (PRR), which identifies the percentage of responses favoring strong STEM education practice. A high PRR should identify a school community with a strong STEM Culture as perceived by the stakeholder groups.

In phase four of the study, content validity of School STEM Culture was analyzed using correlations between the total PRR of each school and the percentage of students pursuing STEM fields within that school. Validity was analyzed using the Item Response

Equality Method, which gives equal weight to every response to an item, and the Stakeholder-Domain Equality Method, which gives equal weight to each stakeholder group for each domain. Each of the methods of correlating the Positive Response Rate to the Percentage of Students Pursuing STEM Fields showed outliers that did not follow the fairly linear pattern of the other schools. When the outliers were removed, a significant correlation existed between the PRR and the Percentage of Students Pursuing STEM Fields using the Item Response Equality Method while showing a non-significant correlation using the Stakeholder-Domain Equality Method.

The outliers for both methods were Fisk High School and Rice High School, with both schools having a much larger group of students who completed the STEM-CAT than the other schools. Rice High School had 166 students and Fisk High School had 173 students complete the STEM-CAT. In comparison, the other six schools averaged a participation of 58 students per school. This large *N* for the student group was amplified in the Item Response Equality Method, and less effective in the Stakeholder-Domain Equality Method. Both schools also were outliers for their percentage of students pursuing STEM fields, with an abnormally high percentage of seniors at Rice High School pursuing STEM fields (64.3%), and an abnormally low percentage of seniors at Fisk High School pursuing STEM fields (45.6%), thus maintaining each school's outlier status regardless of the method of analysis.

Reflection on the STEM-CAT

The STEM-CAT was written with the intention of measuring a School's STEM Culture, which is defined as the beliefs, values, practices, resources, and challenges of a school regarding STEM education as perceived by the parents, teachers, students, and school leadership. Results of this study supported the use of the STEM-CAT as a valid instrument to measure the domains of School STEM Culture with the school community.

Strengths. The instrument has several strengths: (a) gather large amount of data in a short period, (b) allow input from each stakeholder group within the school community, (c) use all stakeholder groups to get a "big picture" look at the perception of STEM education within the school community, and (d) quantify the school's culture for use when trying to improve that culture.

Gathering large amounts of data. One strength of the STEM-CAT is the ability of the instrument to collect a large amount of data about the perceptions of the school community in a fairly short time period. In each of the schools that participated in the study, the administration of the STEM-CAT took place with very little disruption to the school operation. Student input was gathered through short meetings within a homeroom period in most cases, and students completed the instrument within a time period of 5 minutes. Teachers, school leadership, and parents were all asked via email to complete the instrument, and feedback from participating schools was that each group completed the instrument within a 5-minute period as well. Although the STEM-CAT can be administered to a school community within an hour or two of time, the instrument gathers a large amount of quantitative data that can give valuable feedback to the school community regarding the perceptions of those stakeholders regarding STEM education. Feedback was given to participating schools including a summary of positive response rates broken down by stakeholder and domain along with a list of strengths and some recommendations based on the PRR values. These reports often included a summary of beliefs from different stakeholder groups that seemed to align with each other and highlighted values of beliefs that seemed to stand out from the others. Recommendations often included the possibility of including professional development focusing on student centered learning to help teachers learn to facilitate learning rather than always dispense information, as well as suggestions of activities where teachers could develop their skill in relating content to the real world. Administrators provided positive feedback after the reports they received and claimed them to be very helpful.

Input from all stakeholder groups. A second strength of the STEM-CAT is the ability of the instrument to include all stakeholder groups within the data collection. All stakeholder groups within a school community are invested in that community; however, all voices are not always equal when analyzing that community. It is common that the stakeholders employed by the school are often more represented in a study about any domain within school culture, or a study might just focus on students. Of any existing instruments that were discovered in the literature review, none gave an equal voice to all stakeholders. Giving each individual or stakeholder group equal voice allows for a true representation of the total perception of the school's culture, and does not allow for a larger weight placed on any group that might bias results.

Gaining a "big picture" perspective. A third strength of the STEM-CAT is the ability of the instrument to gain a "big picture" perspective of culture by using all stakeholder groups to describe several different perceptions of the culture based on the culture domains. By including all stakeholders over five domains, this increases the scope of the study which allows the STEM-CAT to give schools data on the perception of several groups, thus giving them a more complete picture of the overall culture of the school. Every stakeholder-domain combination has unique perspective on the culture of the school community that cannot be gained from other group responses and adds to the big picture. With the combination of twenty possible stakeholder-domain combinations, this scope gives a wide angle look at the entire culture.

Quantification of school culture. The final strength of the STEM-CAT is the ability of the instrument to quantify a latent construct in School STEM Culture. This construct is a combination of five domains that, in isolation, can be quantified, but no instrument exists that is an attempt to quantify the overall culture itself. Although more work is needed on the instrument, the ability of the instrument to quantify to such an abstract concept is a major strength and will allow the STEM-CAT to be used in further research.

Weaknesses. Conversely, the STEM-CAT also has some weaknesses: (a) the concern that the compilation of data may not clearly quantify the School STEM Culture, (b) the concern that using a small sample of stakeholders may not produce generalizable results for the entire school community, (c) the concern that some of the domains within the instrument are not informative in determining the culture of the school community, (d) the concern that in order to truly understand the makeup of a culture one may need to collect qualitative data, and (e) the need for further analysis of reliability of data through more robust measures.

Compilation of results. One of the overarching purposes of the development of the STEM-CAT was the desire to create an instrument that could quantify the School STEM Culture of a school community with one result. The compilation of this large collection of data could be beneficial to the research community, but is a messy process which does not have a clear cut method. The use of both the Stakeholder-Domain Equality Method as well as the Item Response Equality Method can be argued based on who has a large contribution to the culture of the community. However, sometimes the best decision is not to make a decision and at this point there is not enough data to support choosing one method over another. In the future, more research must be done to support the use of one method or the other based on empirical data. Considering that neither of these methods is clearly more effective than the other, the ability of the instrument to quantify the culture in a way that truly describes the STEM culture is not complete, and will require more research to sharpen the ability of the instrument to measure School STEM Culture.

Generalizability of results. The first major concern regarding the use of the STEM-CAT is whether the instrument is generalizable to the population of the school when a small sample of stakeholders is used in the data collection process. In general, the instrument requires input from 50 students, 50 parents, and all teachers and school leadership. In a school that has a student body population of 1,200 students, this provides input from 4% of the students and parents within the school community. This small percentage could skew the data on both fronts. Considering that often the parents that complete survey requests are the most involved parents, this could bias parent results by not being a representative sample. A school or research study that intends to use the STEM-CAT for the purposes of evaluation of a school's culture might consider increasing the number of students and parents sampled to increase the chances of generalizability.

Uninformative domains. Through the review of literature, five domains within the construct of school culture were identified: beliefs, values, practices, resources, and challenges (Denning & Dargin, 1996; Lindahl, 2006; Zhu, Devos, & Tondeur, 2014). The challenges domain was unique to the study done by Denning and Dargin, and results from that domain may not be particularly informative based on the results of this study.

The standard deviation of the Positive Response Rate for challenges between schools was 12.3%, which shows a large variation between schools which is mirrored within schools. This could be because of the small sample size for many of the school leadership responses, and could be due to the fact that the organization does not deal with challenges as a group and therefore teachers are rather unaware of the challenges in general. Due to this large variation, this domain seems to be fairly uninformative to the study itself.

The values domain might also be considered to be uninformative due to the structure of the items within the instrument. All items on the STEM-CAT are written with Likert scale responses of "strongly agree" to "strongly disagree" with the exception of the values section, which uses the responses of "not important" to "very important." When defining the positive nature of these responses with regard to STEM education, it is hard to draw a cut-off line to determine which responses are positive responses, and which are not. In responding, it does not seem to be uncommon that many responses seem to indicate that all purposes of STEM education are important, leaving a large percentage of positive responses. This might cause this section to be uninformative, and should be revisited before moving forward with using the instrument for research.

Lack of qualitative data. The STEM-CAT is intended to be a quantitative measure of the STEM-Culture of a school, and therefore does not include a qualitative component. Because the domains of school culture are composed of the perceptions of those within the culture, valuable information could be gained from qualitative data collection. A weakness of the STEM-CAT is the lack of this qualitative data. What the STEM-CAT offers in a quick and large scale data collection process, is balanced by the removal of any qualitative information that could give a deeper understanding of the culture for any of the stakeholder perspectives. Future researchers that utilize the STEM-

CAT may consider adding a qualitative piece to the study to support the quantitative results that come from the STEM-CAT to create a more robust measure of culture.

Need for robust analysis of reliability. The reliability of the items in the STEM-CAT was determined using Cronbach's coefficient alpha, which is a widely accepted measure of internal consistency. However, even Cronbach himself questioned the analysis regarding its effectiveness and the fact that it is often overused (Cronbach, 2004.) For a more robust analysis of the reliability of the data, a confirmatory factor analysis should be used in order to determine the internal consistency of the items (Harrington, 2009.) The use of this analysis tool must be the next step in supporting the use of the STEM-CAT as a meaningful measure of School STEM Culture.

Reflection on School STEM Cultural Aspect

School STEM Culture has been defined within this study as a cultural aspect of the overall culture of any school community defined as the beliefs, values, practices, resources, and challenges with regard to STEM education as perceived by the parents, teachers, students, and school leadership. The content validity of this culture aspect was analyzed through this study by using a bivariate correlation between the results of the STEM-CAT and the Percentage of Seniors Pursuing STEM Fields for each particular school.

Strengths. The construct of School STEM Culture has two major strengths that are apparent after the analysis of the content validity part of the study: (a) the theoretical development of the construct has a strong basis rooted in the literature, and (b) the application of this construct has many implications when considering future research.

Theoretical development of the construct. The culture aspect of School STEM Culture is framed based on previous research to be composed of five domains: beliefs, values, practices, resources, and challenges (Denning & Dargin, 1996; Lindahl, 2006.; Zhu, Devos, & Tondeur, 2014). The culture is determined by the perception of these domains by four stakeholder groups: parents, students, teachers, and school leadership. The construct of school culture itself is well grounded in the literature, and this study was an effort to add a level to school culture, termed culture aspect, which is defined as a portion of the culture as defined above with regard to a specific endeavor of the community. If a school community has shared beliefs, then it is not a large step to assume that the community has a shared set of beliefs regarding specific topics such as STEM education. This idea translates to the other four domains of school culture, and thus the framework of culture aspects, specifically School STEM Culture. This framework is a strength of the construct itself, as it is well grounded in theory and should translate to practice.

Application of the construct to future research. In the beginning chapters, a need was established to increase the number of STEM workers being produced in the US. Factors that seem to be deterring students from pursuing STEM fields are coursework difficulty, lack of preparation and lack of understanding what the fields entail (Kelly, 2012). Once the construct of School STEM Culture is considered a valid construct, and once the STEM-CAT is considered a valid instrument to measure School STEM Culture, then researchers can utilize the instrument to complete research to make efforts to improve a school's STEM Culture. The organization of the construct with the five domains and stakeholder groups allows for a researcher to manipulate any of the stakeholder/domain combinations and use the STEM-CAT to determine if there is an overall effect on the School STEM Culture by that intervention.

Weaknesses. For the construct of School STEM Culture to be considered for future research, the following weaknesses should be addressed: (a) the effect of outlier schools on the overall content validity of the construct, and (b) the need for more empirical support for content validity of the construct.

Outlier effect on correlation results. The overall Positive Response Rate from administration of the STEM-CAT was compared with the Percentage of Student Pursuing STEM Fields using bivariate correlation using two methods: the Item Response Equality Method, and the Stakeholder-Domain Equality Method. In the results for both methods something about Fisk High School and Rice High School seems to be different from the other schools. Fisk High School has a percentage of seniors pursuing STEM fields which is significantly lower than the other schools (45.6%). Consequently, Fisk High School also had the largest sample size of seniors that were surveyed (366), which was over 200 more students than the next largest sample. This large sample size could give a percentage which is more accurate than the others which might lead to the lower percentage. Rice High School also had a very large sample of students who completed the STEM-CAT (166) compared to the average (86.5). Rice High School also had a percentage of seniors pursuing STEM fields which was higher than the rest by more than eight percentage points. In the Item Response Equality Method, a third high school (Evans High School) was a third outlier because it had a much larger PRR than the other schools. Using the Item Response Equality Method, after removing the outliers, a significant correlation was found between the Total PRR and Percentage of Students Pursuing STEM Fields ($p=0.043$.) The presence of these outliers could detract from the content validity of School STEM Culture, and suggests that qualitative data could explain the presence of these outliers and how they relate to the overall correlation.

Need for empirical support. In addition to the need to address the outliers in the data, more data should be collected to fully support content validity of School STEM Culture. The correlational analysis was done with a sample size of only eight schools, and should be done with a larger group of schools to reduce the effect of the outliers on the analysis. Because the sample size is very small, the power of the study is also small. To have a power of 80% in the analysis, a sample size of 10 schools would be required. Due to the small sample size, although the construct may be valid, more data must be collected to make a conclusive decision regarding the validity of School STEM Culture.

Limitations of the study

There are four key limitations to this study. The first limitation is the sample size at each participating school with the content validation portion of the study. When administering the STEM-CAT to schools, the number of participants per stakeholder group was not consistent between schools. This is a limitation regardless of which method of analysis is used. In the Item Response Equality Method, any time a stakeholder group has a larger number of participants, that group carries more weight than the others and will bias the results. For example, Fisk High School had 173 students complete the STEM-CAT, and only 67 other participants combined between the other three stakeholder groups. This leads to a tremendous bias towards the students, and in general the students have a lower perception of beliefs as well as practices, so this skews results. In the Stakeholder-Domain Equality Method, a small number of participants for one stakeholder group will bias results. For example, Boggs High School and Rice High School each had two school leadership members complete the STEM-CAT. This means that each of those people had as much input into the total Positive Response Rate as a large number of student participants. Considering the data seems to show that administrators and counselors have a positive outlook on the school's culture in general, this could skew results as well.

The second major limitation for this study is the use of self-reporting for seniors pursuing STEM fields. Each high school was asked to have a sample of seniors complete an online survey stating their intentions as to what their plans were after high school. They first had to choose if they intended to go to a 2/4 year school, the military, or into the workforce. They then had to choose from a list of 12 career clusters as defined by the South Carolina Economic Development Act, and then complete an open-ended question asking what type of job they would like to pursue. The intent was to determine if they planned on pursuing a STEM field or not. Although many of the responses were easily determined as STEM or not, some responses were difficult to determine if the student intended to pursue a STEM field. For example, some students listed "undecided" as their intended career path or sometimes listed the name of the university they intended to attend. These answers were all treated as non-STEM fields to maintain consistency. A very small number of students put silly answers that were not counted at all.

The third limitation to the study is related to the sample size of the number of participating schools. Eight schools elected to participate in the study. For a bivariate correlation to have strong enough power to show significance, an N of 10 should be present. The initial goal of the study was to obtain 20 schools to participate. Falling short of the intended sample size reduces the reliability of the results, especially with the two major outliers within the data. Had the sample size been 20 schools as intended, the two schools with differences may not have been significant. However, the addition of 12 more schools may have shown that the differing schools were in fact just showing a level of variation that did not occur in the other schools in the study. In future research, it might be beneficial to conduct the study with a sample of schools which are more similar demographically to ensure that the variation is due to the STEM Culture of the school, and not other aspects of culture that might obscure the results.

The fourth and final limitation to this study is that the Positive Response Rate does not account for neutral responses. Because neutral responses are not a negative response, it cannot be assumed that if the Positive Response Rate is 72% than the negative response rate was 28%. In fact, several items had very large neutral response percentages, some over 50%. This implies that the positive response rate might be misleading when it is very small. For example, the positive response rate for a question might be 38% for one group of stakeholders; however if the neutral response rate was 50%, this means that only 12% of the respondents responded in a negative way. Considering the neutral responses, the Positive Response Rate might be a misleading idea guiding the reader to think that a low PRR always means a negative perception by the stakeholders and this is not always true. In the future, the author is considering either removing the neutral option within the items, or reporting both a Positive Response Rate and a Negative Response Rate to ensure a true communication of responses.

Implications for Future Research

One of the major strengths of this study is the considerations of the STEM-CAT and the construct of School STEM Culture for use in further research. Future research should be done to further support the use of the STEM-CAT and the construct of School STEM Culture, or future research could be done using the STEM-CAT and the concept of School STEM Culture to improve our schools by using the STEM-CAT to determine the effectiveness of interventions intended to improve the STEM Culture of a school.

Further validation of School STEM Culture. In order to establish School STEM Culture as a cultural aspect which can be used in research, stronger empirical evidence must be provided to support the content validity of the construct. The STEM-CAT has been supported to be reliable and valid, and research can continue to use the STEM-CAT to support the content validity of School STEM Culture. This could be done by continuing to correlate results of the STEM-CAT to the Percentage of Seniors Pursuing STEM Fields, or this could be done by comparing the results of the STEM-CAT to other possible indicators of a strong School STEM Culture. Based on the literature, researchers could use the percentage of students enrolling in higher-level science and mathematics courses as an indicator of a strong STEM Culture, the number of students testing in advanced placement science and mathematics courses, or a comparison of STEM Culture at specialized STEM schools versus traditional schools.

Using the STEM-CAT for school improvement. The intent of the STEM-CAT is to measure the School STEM Culture of a school community as defined as the beliefs, values, practices, resources, and challenges with regard to STEM education as viewed by the parents, teachers, students, and school leadership. If the STEM Culture is defined by the domains and stakeholders, then it seems logical that making a change in any of the stakeholder/domain combinations could change the STEM Culture of the school. The STEM-CAT was designed to be used in research to determine if interventions intended to manipulate any stakeholder/domain combination are effective in changing the STEM Culture of the school. For example, a researcher might design an intervention intended to have a positive effect on parent beliefs about STEM education by creating a marketing campaign within the community targeting parents' beliefs about what students should be doing in STEM courses. That researcher could give the STEM-CAT in the community before the intervention, and subsequently after the intervention and determine if gains have been made in the culture.

Another use of the STEM-CAT to improve schools could be as a metric to determine professional development directions that should be taken by the school to improve STEM education. Based on the school report that can be produced with results from the STEM-CAT, for which a sample can be referenced in Appendix E, school administrators with the help of the STEM-CAT administrator can suggest professional development activities which will strengthen faculty practices in STEM fields.

Addressing sample size. Participation of schools in this study was a challenge, and to truly obtain strong results supporting School STEM Culture, a larger sample size is necessary. Although over 1,000 participants completed the STEM-CAT, the sample size was limited to eight high schools due to difficulty in recruiting schools as noted. For stronger results, a larger sample is needed, including over ten schools. Although the reliability analysis of this study was strong, the content validity needs more support with a larger sample of schools, which could be a large contributor to the lack of significance within the correlational analysis of STEM Culture. This is an issue that must be addressed before the STEM-CAT is able to be a trusted measure of School STEM Culture within research studies.

Both suggestions for future research will serve to strengthen the construct of School STEM Culture as well as the overall view of STEM education in schools. The more the STEM-CAT is used in research, the more empirical data can be collected to empirically support the content validity of the instrument, which may lead to more robust studies in the future.

Implications for K-12 Education

As stated in earlier chapters, the US is in need of a larger production of STEM workers entering the workforce due to an increase in STEM job and the aging workforce (Langdon et al,, 2011; National Science and Math Initiative, 2014). Many areas are implementing specialized STEM schools to move students ahead with a focus on STEM areas. However, to truly move our educational system forward in producing a larger number of STEM workers, we need to attack the problem at traditional, non-specialized schools. The introduction of the culture aspect of School STEM Culture presents the idea that each school has its own STEM Culture that can either help or hinder students in their pursuit of STEM fields. This study was an effort to quantify that STEM Culture to help schools determine where they are in the spectrum of School STEM Culture, and then guide research to determine what interventions are effective in moving a school in one directions or the other on that spectrum in their STEM Culture. This spectrum of School STEM Culture might include reformed STEM educational practices on one side and traditional STEM educational practices on the other. It is important to note that one side of the spectrum is not necessarily better than the other as there is a time and a place for everything. There are times that a teacher must stand up and explain concepts to students, and there are times the teacher must facilitate the students' discovery. The purpose of this spectrum of STEM Culture is not to define "good" or "bad" STEM education, but to identify trends within a school as a diagnostic tool.

The STEM-CAT could be used within the research field as a pre- and post-measure to determine the effectiveness of an intervention intended to affect change in a school's STEM Culture. If a school implements a particular program and the STEM-CAT shows growth from the beginning of implementation to a certain benchmark point, the instrument can be used to empirically support the use of that program. By using the STEM-CAT as a pre- and post-measure, this allows researchers to use interventions intended to affect any stakeholder-domain combination to see if changing that one combination has an effect on the STEM Culture all together. This information could be valuable to both schools and researchers in finding ways to increase involvement in STEM fields.

APPENDICES

APPENDIX A- RESULTS OF FOCUS GROUP ITEM REVIEW

Table A.1

Focus Group Results for Belief Items

Items	Rating	Stakeholder
Students develop many beliefs about how the world works before they ever study about science in school	3	All
Students create their own knowledge by modifying their existing ideas in an effort to make sense of new and past experiences	3	Adult
People are either talented at science or they are not, therefore student achievement in science is a reflection of their natural abilities	3	All
In STEM subject areas, a teacher must explain the concept in a way that is clear and easy to understand for a student to learn	2	All
Students have difficulty learning science and mathematical concepts in school because their beliefs about how the world works are often resistant to change	2	Adult
Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time	3	Adults
Students know very little about science and mathematics before they learn it in school	3	Students
Students learn the most when they are able to explore, discuss, and debate many possible solutions during group activities in STEM courses	2	All
During a lesson, students should explore and conduct their own investigations before the teacher discusses any scientific or mathematical concepts with them*	2	All
During a lesson, teachers should spend more time asking questions that trigger alternative ways of thinking than they do explaining concepts to students*	2	Adults
When students conduct an experiment during a science lesson, the teacher should give step-by-step instructions for the students to follow in order to prevent confusion and get the correct results	3	Students
Investigations should be included in lessons as a way to reinforce the scientific and mathematical concepts students have already learned in class.	3	All
Lessons should be designed in a way that allow students to learn new concepts through exploration instead of through a lecture, a reading or a demonstration*	3	All
During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	3	All
During a lesson, all of the students in the class should be	3	All

encouraged to use the same approach for conducting an experiment or solving a problem		
Assessments in science and mathematics classes should only be given after instruction is completed; that way the teacher can determine if the students have learned the material covered in class	3	All
Students should lead most of the discussion during a lesson in STEM classrooms*	2	All
Students should work independently as much as possible so they do not learn to rely on other students to do their work for them	3	All
In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say	3	All
Teachers should involve students in determining the direction and the focus of a lesson	2	All
Students should accept the ideas and theories presented to them during STEM classes without question	3	All
An excellent STEM teacher is someone who is really good at explaining complicated concepts clearly and simply so that everyone understands	3	All
The teacher should motivate students to finish their work as quickly as possible*	1	All
STEM teachers should primarily act as a resource person, working to support and enhance student investigations rather than explaining how things work	3	All
A good science or mathematics course should focus on only a few concepts a year, but in great detail*	2	All
A STEM curriculum (course) should focus on the basic facts and skills of science and mathematics that students will need in the future	3	Students/ Parents
Students should know that scientific knowledge is discovered using the scientific method	3	All
A STEM curriculum should encourage students to learn and value alternative modes of investigation or problem solving	3	School Adult
To prepare students for college and careers in STEM fields, the curriculum should cover as many different topics as possible over the course of a school year.	2	All
A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics	2	All
Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem and ends with 'reporting the results.'	3	All
A good science curriculum should focus on the history and	2	All

nature of science and how science affects people and societies*		
During a lesson, teachers should present material clearly using some type of visual aid such as PowerPoint or lecture notes	3	All
Students should build their knowledge upon things they have learned in the past	3	All
Learning should be an orderly process, where students are presented material in a sequence to be remembered	3	All
Students should learn at different paces and in different ways within the same classroom	3	All
The main focus of instruction in STEM courses should be on basic skills for students*	1	All
The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner	2	Adult
The responsibility for a student's learning is on the student, with the teacher facilitating that learning*	2	Adult
The main focus of instruction in science and mathematics courses should be on the application of content to the real world around us*	1	All
Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology	3	All
All students can learn science and mathematics if they try hard enough	3	All
There are some students who don't have the ability to learn science and mathematics, no matter how hard they try	3	All
Some people are not science people and should avoid taking science courses	3	All
Some people are not mathematics people and should avoid taking mathematics courses	3	All
Every student in a school can learn calculus if they try hard enough	3	All
When someone makes a claim that something is true, they must present evidence to support their claim	3	Students
People should accept what I tell them without asking for proof	3	Students
My parents believe I can be successful in any STEM class*	2	Students
There are certain classes that my parents discourage me from taking because I might not be successful	3	Students
My counselors encourage me to take advanced STEM courses that might be difficult for me	3	Students
My counselors tend to push me away from STEM courses because I am weak in math and science*	3	Students
My peers often take difficult courses in science and math*	2	Students

In the past, I have avoided signing up for a difficult STEM course because my peers told me not to	2	Students
Teacher planning should be flexible to base lessons on student interest*	1	All
Teacher planning should stick to a schedule to make sure all content standards are covered*	1	All
When taking a science or math course, I should learn more topics on a broad level, or fewer on a deep level? *	1	Students
The content presented in my science and mathematics courses should be based on the design of products*	1	Students
The content presented in my science and mathematics courses should connect content to life outside the classroom*	1	Students
The content presented in my science and mathematics courses should be entirely focused on concepts at hand*	1	Students
The engineering design process should be taught in my science and mathematics courses*	1	Students
My science and mathematics courses should focus on technology design*	1	Students
Students should be exposed to STEM careers during the school day	2	All
I have an awareness of existing STEM careers*	3	All
People involved in STEM careers must be enrolled in Advanced Placement courses in high school	3	All
People involved in STEM careers must think math and science are easy*	1	All
Certain races or genders are better at STEM classes than others	3	All
Anyone can be successful in STEM careers	3	All
There are lots of opportunities for girls in STEM field*	1	All
A girl can become the CEO of a major engineering industry	3	All
Someone who is a minority can become the CEO of a major industry	3	All

*Indicates an item which was removed

Table A.2

Focus Group Results for Values Items

Items	Rating	Stakeholder
In a science or math classroom, it is important that the teacher must set the tone early that he/she is in charge of the learning.*	2	All
My success in science, math, engineering and technology depends on the way my teachers teach *	2	Students

My school should devote more funding to STEM education than it does to other school programs.	3	All
The most important thing that affects my education in science, math, engineering and technology is my ability level when I start high school *	1	All
The main goal of a STEM teacher should be to help students grow within their social norm*	1	All
Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important) To accumulate knowledge about the world around us + To prepare for college/university studies only if the courses apply to their major or career - To be able to have an educated debate about policies in our community + To be able to understand issues in the government when voting + To understand how concepts are used to assist in their desired way of life + To be able to make educated decisions about moral and ethical issues in current events + To be able to understand the issues in current scientific research + To understand how technology is developed for the future +	3	All
I would identify my relationship with science as I am aware of science, but it is not relevant to my world I accept that science is important I like science and enjoy participating in science I seek out scientific activities for enjoyment I am considering a science field in the future	2	Students
I would identify my relationship with mathematics as I am aware of mathematics, but it is not relevant to my world I accept that mathematics is important I like mathematics and enjoy participating in mathematics I seek out mathematic activities for enjoyment I am considering a mathematics field in the future	2	Students
I would identify my relationship with engineering as I am aware of engineering, but it is not relevant to	2	Students

my world		
I accept that engineering is important		
I like engineering, and enjoy participating in engineering		
I seek out engineering activities for enjoyment		
I am considering an engineering field in the future		
I would identify my relationship with technology as	2	Students
I am aware of technology, but it is not relevant to my world		
I accept that technology is important		
I like technology and enjoy using or developing new technologies		
I seek out new technologies for enjoyment		
I am considering a technology field in the future		

*Indicates an item which was removed

Table A.3
Focus Group Results for Resources Items

Items	Rating	Stakeholder
Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management	3	School Adults
Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching.	3	Students
The class sizes in STEM classes are below the state average.	3	School Adults
I am satisfied with the size of classes in my school.	3	All
STEM teachers in my school are paid above the state average.	3	School Adults
Teacher salaries in my school are too low for the area in which we live.	2	Adults
Classrooms in my school building are too small and create a crowded environment when teaching. *	2	All
Classes in my school take place in portable classrooms in my school. *	1	All
The classrooms in my school building are large enough to teach without being crowded.	2	School Adults
I often work in groups larger than 4 in my STEM courses because of lack of materials.	3	Students
STEM teachers have the resources to do activities in their classrooms with groups of 3 or less.	1	School Adults
I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials.	3	Students
My school has engineering and technology programs	3	Students

which use expensive materials.		
My school only offers the typical mathematics and science courses.	3	Students
Representatives of our school meet with business and community members to discuss STEM related community issues.	3	School Adults
I have opportunities to discuss curriculum with business/industry members in my community.	3	School Adults
Our school offers extra-curricular activities in STEM which involve business/industry members.	3	All
Our community offers local field trip opportunities which relate to STEM fields.*	3	All
We have multiple opportunities to take field trips for STEM courses. *	2	Students
I live in an area where STEM fields are important.*	1	All
Teachers in my school have access to sufficient resources to complete activities/labs.	3	All
STEM teachers skip labs/activities when they do not have access to the necessary materials.	2	School Adults
Teachers often purchase materials for activities/labs with their own money.	3	School Adults
There is sufficient access to technology in classrooms for curricular purposes.	2	Adults
I get to use technology in my classes.*	1	Students
We have technology in my classroom, but students never get to use it.	3	Students
Students in my school have access to everyday materials such as pens, pencils and calculators.	2	All

*Indicates an item which was removed

Table A.4
Focus Group Results for Challenges Items

Items	Rating	Stakeholder
My school has identified challenges to our science, math, engineering and technology program	3	School Adults
When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program	3	School Adults
My school involves students and parents in developing our science, math, engineering and technology program	3	School Adults
My school has implemented our program to take on our challenges in science, math, engineering and technology	3	School Adults
My school made positive changes to effectively	2	Adults

address challenges in our science, math, engineering and technology program		
After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement	3	Adults

Table A.5
Focus Group Results for Practices Items

Items	Rating	Stakeholder
My science and math teachers begin units/lessons with an essential question and refer to that question throughout the entire unit/lesson	3	Students
When my science and math teachers are teaching, they talk about how concepts connect to the real world	3	Students
I struggle to understand what my teachers are teaching in science and math because I do not see how it applies to me	3	Students
Units in my math and science courses may have a theme which is not a science or math concept*	1	All
My science and math lessons begin with an interesting idea that gets me involved in the lessons	2	Students
The beginning of my math and science lessons begin with a review activity from the class before	2	Students
My math and science teachers ask me what I know about a topic before we begin studying the topic	3	Students/ Teachers
My math and science teachers use my existing knowledge to help me build new knowledge	3	Students/ Teachers
When my math and science teachers begin a new unit, they act as if I do not have any previous understanding of the concepts	3	Students
My math and science teachers give me time to reflect on my learning	2	Students
My math and science teachers check with me to make sure I have a good understanding of concepts	3	Students
My math and science teachers work hard to ensure that all students progress at the same pace	2	Students
My math and science teachers begin a unit with some type of pre-assessment	3	Students
In STEM classes, students engage in hands-on activities after the material has been taught	3	Students/ Teachers
Teachers use labs and activities in my STEM classes to help students understand the material *	2	Students
Labs and activities in STEM courses do not connect to the class content*	2	Students

In my math classes, we do hands on activities	3	Students
Hands on activities in my math classes help me better understand the material *	1	Students
Homework in my math classes consists of a large number of practice problems	3	Students
When problem solving in math, we solve problems to get the correct answer from the book	2	Students
When solving problems in math class, we solve problems related to real life scenarios.	3	Students
My teachers ask me to justify my answers in STEM classes.	3	Students
The main focus in my science classes is obtaining the correct answer *	2	Students
In my math and science classes, I have to explain concepts to other students	3	Students
In my math and science classes, I have to justify my ideas to other students	3	Students
I work in groups to solve problems in my math classes	3	Students
I work in groups in my science classes	3	Students
Math teachers work together to develop lessons	1	All
Science teachers work together to develop lessons	2	All
Math and science teachers in my school often know what the other teachers are doing	1	Students
Math and science teachers in my school respect each other *	1	All
Math and science teachers in my school think the other math and science teachers do a good job	1	All
Based on my experiences in class, I have a good understanding of what it is like to do scientific research	3	Students
Based on my experiences in school, I have a good understanding of how an engineer develops a product	3	Students
I have had to defend a product or conclusion in my STEM classes	3	Students
Teachers are free to make the instructional decisions in STEM classes	3	School Adults
My math and science teachers could make class more interesting if they were not bound by state standards *	1	Students
My teachers in math and science motivate me to want to learn about STEM fields	2	Students

*Indicates an item which was removed

APPENDIX B- FINAL SURVEY ITEMS AFTER EXPERT REVIEW

Parent Survey Items

29 total items

Beliefs

1. There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.
2. The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.
3. STEM teachers should primarily act as a resource person, working to support and enhance student investigations rather than explaining how things work.
4. Students should build their knowledge upon things they have learned in the past.
5. Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.
6. During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.
7. Learning should be an orderly process, where students are presented material in a sequence to be remembered.
8. Teachers should involve students in determining the direction and the focus of a lesson.
9. Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.
10. Students should be exposed to STEM careers during the school day.
11. During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.
12. Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.
13. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.
14. Students should accept the ideas and theories presented to them during STEM classes without question.
15. Investigations should be included in lessons as a way to reinforce the scientific and mathematical concepts students have already learned in class.
16. A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.
17. Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'

Values

1. My school should devote more funding to STEM education than it does to other school programs.
2. Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).
    a. To accumulate knowledge about the world around us.
    b. To be able to have an educated debate about policies in our community.
    c. To understand how concepts are used to assist in their desired way of life.

d. To be able to make educated decisions about moral and ethical issues in current events.
e. To be able to understand the issues in current scientific research.

Resources

1. I am satisfied with the size of classes in my school.
2. Teacher salaries in my school are too low for the area in which we live.
3. Our school offers extra-curricular activities in STEM which involve business/industry members.
4. Teachers in my school have access to sufficient resources to complete activities/labs.
5. There is sufficient access to technology in classrooms for curricular purposes.
6. Students in my school have access to everyday materials such as pens, pencils and calculators.

School Leadership Survey Items

41 total items

Beliefs

18. There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.
19. The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.
20. STEM teachers should primarily act as a resource person, working to support and enhance student investigations rather than explaining how things work.
21. Students should build their knowledge upon things they have learned in the past.
22. Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.
23. During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.
24. Learning should be an orderly process, where students are presented material in a sequence to be remembered.
25. Teachers should involve students in determining the direction and the focus of a lesson.
26. Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.
27. Students should be exposed to STEM careers during the school day.
28. During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.
29. Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.
30. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.
31. Students should accept the ideas and theories presented to them during STEM classes without question.
32. Investigations should be included in lessons as a way to reinforce the scientific and mathematical concepts students have already learned in class.
33. A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.

34. Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'

Values

3. My school should devote more funding to STEM education than it does to other school programs.
4. Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).
    a. To accumulate knowledge about the world around us.
    b. To be able to have an educated debate about policies in our community.
    c. To understand how concepts are used to assist in their desired way of life.
    d. To be able to make educated decisions about moral and ethical issues in current events.
    e. To be able to understand the issues in current scientific research.

Resources

1. Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management. Teacher salaries in my school are too low for the area in which we live.
2. Teacher salaries in my school are too low for the area in which we live.
3. Representatives of our school meet with business and community members to discuss STEM related community issues.
4. I have opportunities to discuss curriculum with business/industry members in my community.
5. Our school offers extra-curricular activities in STEM which involve business/industry members.
6. STEM teachers skip labs/activities when they do not have access to the necessary materials.
7. Teachers often purchase materials for activities/labs with their own money.
8. There is sufficient access to technology in classrooms for curricular purposes.
9. Students in my school have access to everyday materials such as pens, pencils and calculators.

Challenges

1. My school has identified challenges to our science, math, engineering and technology program.
2. When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.
3. My school involves students and parents in developing our science, math, engineering and technology program.
4. My school has implemented our program to take on our challenges in science, math, engineering and technology.
5. My school made positive changes to effectively address challenges in our science, math, engineering and technology program.
6. After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.

Practices

1. Math teachers work together to develop lessons.
2. Science teachers work together to develop lessons.
3. Teachers are free to make the instructional decisions in STEM classes.

Student Survey Items

40 total items

Beliefs

35. There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.
36. The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.
37. STEM teachers should primarily act as a resource person, working to support and enhance student investigations rather than explaining how things work.
38. Students should build their knowledge upon things they have learned in the past.
39. During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.
40. Learning should be an orderly process, where students are presented material in a sequence to be remembered.
41. Teachers should involve students in determining the direction and the focus of a lesson.
42. Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.
43. During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.
44. Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.
45. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.
46. Students should accept the ideas and theories presented to them during STEM classes without question.
47. Investigations should be included in lessons as a way to reinforce the scientific and mathematical concepts students have already learned in class.
48. Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'
49. When someone makes a claim that something is true, they must present evidence to support their claim.
50. My counselors encourage me to take advanced STEM courses that might be difficult for me.
51. In the past, I have avoided signing up for a difficult STEM course because my peers told me not to.

Values

5. My school should devote more funding to STEM education than it does to other school programs.
6. Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).
    a. To accumulate knowledge about the world around us.

b. To be able to have an educated debate about policies in our community.
c. To understand how concepts are used to assist in their desired way of life.
d. To be able to make educated decisions about moral and ethical issues in current events.
e. To be able to understand the issues in current scientific research.

Resources

10. Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching.
11. I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials.
12. Teachers in my school have access to sufficient resources to complete activities/labs.
13. We have technology in my classroom, but students never get to use it.
14. Students in my school have access to everyday materials such as pens, pencils and calculators.

Practices

1. When my science and math teachers are teaching, they talk about how concepts connect to the real world.
2. I struggle to understand what my teachers are teaching in science and math because I do not see how it applies to me.
3. My science and math lessons begin with an interesting idea that gets me involved in the lessons.
4. My math and science lessons begin with a review activity from the class before.
5. My math and science teachers ask me what I know about a topic before we begin studying the topic.
6. When my math and science teachers begin a new unit, they act as if I do not have any previous understanding of the concepts.
7. My math and science teachers check with me to make sure I have a good understanding of concepts.
8. In STEM classes, students engage in hands-on activities after the material has been taught.
9. When solving problems in math class, we solve problems related to real life scenarios.
10. My teachers ask me to justify my answers in STEM classes.
11. In my math and science classes, I have to explain concepts to other students.
12. I have had to defend a product or conclusion in my STEM classes.

Teacher Survey Items

43 items

Beliefs

52. There are some students who don’t have the ability to learn science and mathematics, no matter how hard they try.
53. The responsibility for students’ learning belongs to the teacher, who must present the material in a clear and logical manner.
54. STEM teachers should primarily act as a resource person, working to support and enhance student investigations rather than explaining how things work.
55. Students should build their knowledge upon things they have learned in the past.

56. Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.
57. During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.
58. Learning should be an orderly process, where students are presented material in a sequence to be remembered.
59. Teachers should involve students in determining the direction and the focus of a lesson.
60. Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.
61. Students should be exposed to STEM careers during the school day.
62. During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.
63. Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.
64. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.
65. Students should accept the ideas and theories presented to them during STEM classes without question.
66. Investigations should be included in lessons as a way to reinforce the scientific and mathematical concepts students have already learned in class.
67. A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.
68. Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'

Values

7. My school should devote more funding to STEM education than it does to other school programs.
8. Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).
    a. To accumulate knowledge about the world around us.
    b. To be able to have an educated debate about policies in our community.
    c. To understand how concepts are used to assist in their desired way of life.
    d. To be able to make educated decisions about moral and ethical issues in current events.
    e. To be able to understand the issues in current scientific research.

Resources

15. Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management. Teacher salaries in my school are too low for the area in which we live.
16. Teacher salaries in my school are too low for the area in which we live.
17. Representatives of our school meet with business and community members to discuss STEM related community issues.
18. I have opportunities to discuss curriculum with business/industry members in my community.

19. Our school offers extra-curricular activities in STEM which involve business/industry members.
20. STEM teachers skip labs/activities when they do not have access to the necessary materials.
21. Teachers often purchase materials for activities/labs with their own money.
22. There is sufficient access to technology in classrooms for curricular purposes.
23. Students in my school have access to everyday materials such as pens, pencils and calculators.

Challenges

7. My school has identified challenges to our science, math, engineering and technology program.
8. When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.
9. My school involves students and parents in developing our science, math, engineering and technology program.
10. My school has implemented our program to take on our challenges in science, math, engineering and technology.
11. My school made positive changes to effectively address challenges in our science, math, engineering and technology program.
12. After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.

Practices

1. Math and science teachers use a student's existing knowledge to help build new knowledge.
2. In STEM classes, students engage in hands-on activities after the material has been taught.
3. Math teachers work together to develop lessons.
4. Science teachers work together to develop lessons.
5. Teachers are free to make the instructional decisions in STEM classes.

APPENDIX C: SAMPLE SURVEY RESPONSES OF SENIORS REGARDING POST-SECONDARY PLANS

Table C.1
Sample Percent STEM Responses as self-reported by seniors

Intended Field	Career Cluster	STEM Y or N
Biology/Zoology	Agriculture, Food and Natural Resources	Y
	Architecture and Construction	Y
undecided	Arts, Audio-Video Technology & Communications	N
Theater Design, Textiles & Apparel	Arts, Audio-Video Technology & Communications	N
Theater	Arts, Audio-Video Technology & Communications	N
University of Northern Iowa	Arts, Audio-Video Technology & Communications	N
Communications or Business	Arts, Audio-Video Technology & Communications	Y
Undecided	Arts, Audio-Video Technology & Communications	N
undecided	Business, Management & Administration	N
university of iowa	Business, Management & Administration	N
Business	Business, Management & Administration	N
Saint Leo University	Business, Management & Administration	N
University of Northern Iowa	Business, Management & Administration	N
Education	Education and Training	N
Truman State University, communication disorders	Education and Training	N
University of Northern Iowa	Education and Training	N
University of Iowa	Education and Training	N
Biology: Biomedical	Health Science	Y
Biology	Health Science	Y
Nursing	Health Science	Y
University of Northern Iowa	Health Science	Y
University of Northern Iowa Major:BioChem	Health Science	Y
Exercise Science	Health Science	Y

University of Northern Iowa	Health Science	Y
Iowa State University	Health Science	Y
Truman State, Communication Disorders	Human Services	N
Iowa state university	Marketing, Sales and Service	N
Undecided	STEM	Y
Electrical Engineering	STEM	Y
Mechanical Engineering	STEM	Y
Bioinformatics	STEM	Y
Electrical Engineering	STEM	Y
Matahematics	STEM	Y
Indiana Wesleyan University/Biochemistry	STEM	Y
Mathematics - Actuarial Science	STEM	Y
Biomedical Engineering	STEM	Y
Chemistry	STEM	Y
Chemistry and Astronomy	STEM	Y
Mechanical Engineering	STEM	Y
Mechanical Engineering	STEM	Y
Iowa State	STEM	Y
Math, Science, Biology	STEM	Y
Mechanical Engineering	STEM	Y
St Olaf College	STEM	Y
Equine Management	Agriculture, Food and Natural Resources	Y
undecided	Architecture and Construction	Y
hawkeye community college	Architecture and Construction	Y
undecided	Architecture and Construction	Y
Graphic Design	Arts, Audio-Video Technology & Communications	N
Hawkeye Community College	Arts, Audio-Video Technology & Communications	N
Hawkeye Community College	Education and Training	N
Job corp	Health Science	Y
Kirkwood Community College	Health Science	Y
Hawkeye community college	Health Science	Y
Hawkeye	Human Services	N
undecided	STEM	Y

APPENDIX D: STEM-CAT RESPONSE SUMMARY FOR RICEHIGH SCHOOL

Table D.1

Parent Responses for Rice High School (n=6)

ITEM	%Strongly Disgree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
PB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**33.3**	**50.0**	**16.7**	**0.0**	**0.0**	**83.3**
PB 1.2-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**33.3**	**0.0**	**0.0**	**33.3**	**33.3**	**66.7**
PB 1.3-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**16.7**	**16.7**	**0.0**	**33.3**	**33.3**	**66.7**
PB 1.4- Students should be exposed to STEM careers during the school day.	**33.3**	**16.7**	**0.0**	**33.3**	**16.7**	**50.0**
PB 1.5- During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**33.3**	**16.7**	**0.0**	**33.3**	**16.7**	**50.0**
PB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**33.3**	**16.7**	**0.0**	**33.3**	**16.7**	**50.0**
PV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
PV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**50.0**	**50.0**	**100.0**
PV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**0.0**	**0.0**	**66.7**	**33.3**	**100.0**
PV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**0.0**	**50.0**	**50.0**	**100.0**

PV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	16.7	0.0	0.0	50.0	33.3	83.3
PV 2.5- To be able to understand the issues in current scientific research.	16.7	0.0	16.7	33.3	33.3	66.7
PR 1.1- Teachers in my school have access to sufficient resources to complete activities/labs.	0.0	33.3	50.0	16.7	0.0	16.7
PR 1.2- Students in my school have access to everyday materials such as pens, pencils and calculators.	0.0	0.0	0.0	33.3	66.7	100.0
PR 1.3- There is sufficient access to technology in classrooms for curricular purposes.	0.0	16.7	0.0	50.0	33.3	83.3

Table D.2
Student Responses for Rice High School (n=112)

ITEM	%Strongly Disagree	% Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SB 1.1- There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	12.5	42.0	17.0	21.4	7.1	54.5
SB 1.2- In the past, I have avoided signing up for a difficult STEM course because my peers told me not to.	30.4	39.3	14.3	12.5	3.6	69.6
SB 1.3- 4. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	1.8	1.8	7.1	54.5	33.9	89.2
SB 1.4- My counselors encourage me to take advanced STEM courses that might be difficult for me.	1.8	15.2	34.8	33.0	15.2	48.2

SB 1.5- Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**1.8**	**1.8**	**9.8**	**49.1**	**36.6**	**86.5**
SB 1.6- Students should build their knowledge upon things they have learned in the past.	**3.6**	**0.0**	**11.6**	**52.7**	**32.1**	**84.8**
SV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SV 2.1- To accumulate knowledge about the world around us.	**0.0**	**1.8**	**15.2**	**39.3**	**42.0**	**82.7**
SV 2.2-To be able to have an educated debate about policies in our community.	**1.8**	**5.4**	**27.7**	**45.5**	**17.9**	**64.5**
SV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**2.7**	**18.8**	**52.7**	**24.1**	**78.2**
SV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**3.6**	**16.1**	**39.3**	**39.3**	**80.0**
SV 2.5- To be able to understand the issues in current scientific research.	**4.5**	**4.5**	**18.8**	**39.3**	**31.3**	**71.8**
SR 1.1- Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching	**8.9**	**42.0**	**21.4**	**17.0**	**8.9**	**51.8**
SR 1.2- I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials	**13.4**	**47.3**	**19.6**	**13.4**	**4.5**	**61.8**
SP 1.1- When my science and math teachers are teaching, they talk about how concepts connect to the real world.	**5.4**	**17.0**	**23.2**	**42.0**	**8.9**	**52.8**
SP 1.2- I struggle to understand what my teachers are teaching in science and math because I do not see how it applies to me.	**9.8**	**33.0**	**26.8**	**19.6**	**7.1**	**44.4**

SP 1.3- My science and math lessons begin with an interesting idea that gets me involved in the lessons.	**6.3**	**23.2**	**39.3**	**24.1**	**3.6**	**28.7**
SP 1.4- My math and science teachers ask me what I know about a topic before we begin studying the topic.	**7.1**	**22.3**	**27.7**	**37.5**	**1.8**	**40.7**
SP 1.5- My math and science teachers check with me to make sure I have a good understanding of concepts.	**8.9**	**13.4**	**25.0**	**42.0**	**7.1**	**50.9**
SP 1.6- When solving problems in math class, we solve problems related to real life scenarios.	**12.5**	**17.0**	**21.4**	**34.8**	**9.8**	**46.7**
SP 1.7- My teachers ask me to justify my answers in STEM classes.	**3.6**	**7.1**	**36.6**	**39.3**	**8.9**	**50.5**
SP 1.8- In my math and science classes, I have to explain concepts to other students.	**8.9**	**8.0**	**29.5**	**43.8**	**6.3**	**51.9**
SP 1.9- I have had to defend a product or conclusion in my STEM classes.	**9.8**	**14.3**	**39.3**	**25.0**	**7.1**	**33.6**

Table D.3
Teacher Responses for Rice High School (n=21)

ITEM	**%Strongly Disagree**	**% Disagree**	**% Neutral**	**%Agree**	**%Strongly Agree**	**% Positive Response**
TB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**38.1**	**42.9**	**14.3**	**4.8**	**0.0**	**81.0**
TB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	**4.8**	**19.0**	**28.6**	**47.6**	**0.0**	**47.6**
TB 1.3-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**4.8**	**4.8**	**4.8**	**23.8**	**61.9**	**85.7**
TB 1.4-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**4.8**	**4.8**	**4.8**	**52.4**	**33.3**	**85.7**

TB 1.5-Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'	**4.8**	**33.3**	**47.6**	**14.3**	**0.0**	**38.1**
TB 1.6-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	**14.3**	**61.9**	**14.3**	**4.8**	**4.8**	**76.2**
TB 1.7-Learning should be an orderly process, where students are presented material in a sequence to be remembered.	**9.5**	**47.6**	**38.1**	**0.0**	**4.8**	**57.1**
TB 2.1-The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	**14.3**	**38.1**	**33.3**	**4.8**	**4.8**	**55.0**
TB 2.2-Students should be exposed to STEM careers during the school day.	**0.0**	**4.8**	**23.8**	**38.1**	**28.6**	**70.0**
TB 2.3-During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**0.0**	**4.8**	**9.5**	**61.9**	**19.0**	**85.0**
TB 2.3-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**0.0**	**4.8**	**4.8**	**42.9**	**38.1**	**89.5**
TB 2.4-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	**4.8**	**47.6**	**33.3**	**4.8**	**4.8**	**10.0**
TB 2.5-Students should build their knowledge upon things they have learned in the past.	**0.0**	**4.8**	**9.5**	**57.1**	**23.8**	**85.0**
TV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
TV 2.1- To accumulate knowledge about the world	**0.0**	**0.0**	**4.8**	**28.6**	**61.9**	**95.0**

around us.						
TV 2.2-To be able to have an educated debate about policies in our community.	0.0	4.8	23.8	38.1	28.6	70.0
TV 2.3- To understand how concepts are used to assist in their desired way of life.	0.0	0.0	14.3	42.9	38.1	85.0
TV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	0.0	0.0	9.5	47.6	38.1	90.0
TV 2.5- To be able to understand the issues in current scientific research.	0.0	0.0	19.0	47.6	28.6	80.0
TR 1.1- Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management	4.8	9.5	33.3	38.1	9.5	50.0
TR 1.2- STEM teachers skip labs/activities when they do not have access to the necessary materials.	9.5	9.5	47.6	28.6	0.0	20.0
TR 1.3-Students in my school have access to everyday materials such as pens, pencils and calculators.	0.0	0.0	14.3	38.1	42.9	85.0
TR 1.4-Teachers often purchase materials for activities/labs with their own money.	4.8	14.3	38.1	28.6	9.5	20.0
TR 1.5- There is sufficient access to technology in classrooms for curricular purposes.	0.0	14.3	19.0	38.1	23.8	65.0
TC 1.1- My school has identified challenges to our science, math, engineering and technology program.	4.8	4.8	57.1	23.8	4.8	30.0
TC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	0.0	9.5	57.1	23.8	4.8	30.0
TC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	0.0	14.3	66.7	9.5	4.8	15.0

TC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	**0.0**	**0.0**	**47.6**	**33.3**	**14.3**	**50.0**
TC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**47.6**	**38.1**	**9.5**	**50.0**
TC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	**0.0**	**0.0**	**66.7**	**23.8**	**4.8**	**30.0**

Table D.4
School Leadership Responses for Rice High School (n=1)

ITEM	**%Strongly Disagree**	**%Disagree**	**%Neutral**	**%Agree**	**%Strongly Agree**	**% Positive Response**
SLB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**0.0**	**100.0**	**0.0**	**0.0**	**0.0**	**100.0**
SLB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLB 1.3-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	**0.0**	**100.0**	**0.0**	**0.0**	**0.0**	**100.0**
SLB 1.4- Learning should be an orderly process, where students are presented material in a sequence to be remembered.	**0.0**	**100.0**	**0.0**	**0.0**	**0.0**	**100.0**
SLB 1.5- The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	**0.0**	**100.0**	**0.0**	**0.0**	**0.0**	**100.0**

SLB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLB 1.7-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**0.0**
SLB 1.8-Students should build their knowledge upon things they have learned in the past.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SLV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**100.0**
SLV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**100.0**
SLV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**100.0**
SLV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**100.0**
SLP 1.1- Math teachers work together to develop lessons.	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**100.0**
SLP 1.2- Science teachers work together to develop lessons.	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**100.0**
SLC 1.1- My school has identified challenges to our science, math, engineering and technology program.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**100.0**

SLC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**

APPENDIX E: STEM-CAT RESPONSE SUMMARY FOR FISK HIGH SCHOOL

Table E.1
Parent Responses for Fisk High School (n=28)

ITEM	%Strongly Disgree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
PB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**32.1**	**32.1**	**7.1**	**28.6**	**0.0**	**64.3**
PB 1.2-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**0.0**	**0.0**	**0.0**	**46.4**	**53.6**	**100.0**
PB 1.3-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**0.0**	**0.0**	**0.0**	**53.6**	**46.4**	**100.0**
PB 1.4- Students should be exposed to STEM careers during the school day.	**0.0**	**0.0**	**3.6**	**71.4**	**25.0**	**96.4**
PB 1.5- During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**0.0**	**0.0**	**7.1**	**53.6**	**39.3**	**92.9**
PB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**0.0**	**3.6**	**0.0**	**39.3**	**57.1**	**96.4**
PV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
PV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**7.1**	**39.3**	**53.6**	**92.9**
PV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**14.3**	**17.9**	**39.3**	**28.6**	**67.9**
PV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**3.6**	**17.9**	**32.1**	**46.4**	**78.6**
PV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**3.6**	**17.9**	**25.0**	**53.6**	**78.6**
PV 2.5- To be able to understand the issues in current scientific	**0.0**	**7.1**	**3.6**	**50.0**	**39.3**	**89.3**

research.						
PR 1.1- Teachers in my school have access to sufficient resources to complete activities/labs.	**0.0**	**10.7**	**25.0**	**57.1**	**7.1**	**64.3**
PR 1.2- Students in my school have access to everyday materials such as pens, pencils and calculators.	**0.0**	**7.1**	**3.6**	**50.0**	**39.3**	**89.3**
PR 1.3- There is sufficient access to technology in classrooms for curricular purposes.	**0.0**	**10.7**	**14.3**	**60.7**	**14.3**	**75.0**

Table E.2
Student Responses for Fisk High School (n=195)

ITEM	%Strongly Disagree	% Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SB 1.1- There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**13.8**	**30.3**	**18.5**	**30.8**	**6.7**	**44.1**
SB 1.2- In the past, I have avoided signing up for a difficult STEM course because my peers told me not to.	**22.1**	**32.3**	**28.2**	**14.9**	**2.6**	**54.4**
SB 1.3- 4. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**0.5**	**3.6**	**13.8**	**54.4**	**27.2**	**82.0**
SB 1.4- My counselors encourage me to take advanced STEM courses that might be difficult for me.	**6.7**	**16.9**	**45.1**	**22.6**	**8.2**	**30.9**
SB 1.5- Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**0.5**	**3.1**	**14.9**	**54.4**	**27.2**	**81.5**

SB 1.6- Students should build their knowledge upon things they have learned in the past.	**0.5**	**2.6**	**19.0**	**56.4**	**21.5**	**77.9**
SV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SV 2.1- To accumulate knowledge about the world around us.	**2.1**	**1.5**	**13.8**	**41.5**	**39.0**	**82.2**
SV 2.2-To be able to have an educated debate about policies in our community.	**3.6**	**3.6**	**33.3**	**35.4**	**21.0**	**58.2**
SV 2.3- To understand how concepts are used to assist in their desired way of life.	**2.6**	**3.6**	**22.6**	**44.1**	**25.1**	**70.7**
SV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**1.5**	**3.6**	**17.4**	**41.0**	**33.8**	**76.8**
SV 2.5- To be able to understand the issues in current scientific research.	**2.6**	**3.6**	**26.2**	**41.5**	**24.1**	**67.0**
SR 1.1- Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching	**11.8**	**27.2**	**30.8**	**21.0**	**6.2**	**40.2**
SR 1.2- I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials	**19.0**	**31.3**	**27.7**	**12.8**	**6.2**	**51.9**
SP 1.1- When my science and math teachers are teaching, they talk about how concepts connect to the real world.	**8.2**	**11.8**	**31.3**	**37.9**	**6.2**	**46.2**
SP 1.2- I struggle to understand what my teachers are teaching in science and math because I do not see how it applies to me.	**8.2**	**24.6**	**35.9**	**19.0**	**6.7**	**34.8**
SP 1.3- My science and math lessons begin with an interesting idea that gets me involved in the lessons.	**8.2**	**15.9**	**37.9**	**27.7**	**5.1**	**34.6**
SP 1.4- My math and science teachers ask me what I know about a topic before we begin studying the topic.	**4.6**	**13.8**	**34.9**	**34.9**	**7.2**	**44.1**

SP 1.5- My math and science teachers check with me to make sure I have a good understanding of concepts.	**4.1**	**14.4**	**27.2**	**39.0**	**10.3**	**51.9**
SP 1.6- When solving problems in math class, we solve problems related to real life scenarios.	**9.7**	**16.9**	**36.4**	**26.2**	**6.2**	**33.9**
SP 1.7- My teachers ask me to justify my answers in STEM classes.	**5.1**	**11.3**	**41.5**	**30.8**	**6.7**	**39.2**
SP 1.8- In my math and science classes, I have to explain concepts to other students.	**4.6**	**10.8**	**33.8**	**36.9**	**8.7**	**48.1**
SP 1.9- I have had to defend a product or conclusion in my STEM classes.	**7.2**	**9.7**	**47.7**	**23.1**	**6.2**	**31.1**

Table E.3
Teacher Responses for Fisk High School (n=37)

ITEM	%Strongly Disagree	% Disagree	% Neutral	%Agree	%Strongly Agree	% Positive Response
TB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	45.9	48.6	0.0	5.4	0.0	94.6
TB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	5.4	24.3	29.7	35.1	5.4	40.5
TB 1.3-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	0.0	0.0	0.0	37.8	62.2	100.0
TB 1.4-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	0.0	0.0	5.4	43.2	51.4	94.6
TB 1.5-Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'	8.1	29.7	27.0	29.7	2.7	38.9

TB 1.6-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	27.0	56.8	10.8	5.4	0.0	83.8
TB 1.7-Learning should be an orderly process, where students are presented material in a sequence to be remembered.	18.9	27.0	21.6	32.4	0.0	45.9
TB 2.1-The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	18.9	43.2	24.3	13.5	0.0	62.2
TB 2.2-Students should be exposed to STEM careers during the school day.	0.0	0.0	16.2	62.2	21.6	83.8
TB 2.3-During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	0.0	2.7	2.7	43.2	48.6	94.4
TB 2.3-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	0.0	0.0	2.7	48.6	48.6	97.3
TB 2.4-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	18.9	40.5	21.6	18.9	0.0	18.9
TB 2.5-Students should build their knowledge upon things they have learned in the past.	0.0	0.0	8.1	67.6	24.3	91.9
TV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
TV 2.1- To accumulate knowledge about the world around us.	0.0	0.0	0.0	35.1	64.9	100.0
TV 2.2-To be able to have an educated debate about policies in our community.	0.0	2.7	8.1	32.4	56.8	89.2
TV 2.3- To understand how concepts are used to assist in their desired way of life.	0.0	0.0	8.1	37.8	54.1	91.9

TV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**8.1**	**21.6**	**70.3**	**91.9**
TV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**5.4**	**10.8**	**51.4**	**32.4**	**83.8**
TR 1.1- Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management	**2.7**	**10.8**	**48.6**	**29.7**	**8.1**	**37.8**
TR 1.2- STEM teachers skip labs/activities when they do not have access to the necessary materials.	**0.0**	**10.8**	**62.2**	**21.6**	**5.4**	**10.8**
TR 1.3-Students in my school have access to everyday materials such as pens, pencils and calculators.	**0.0**	**0.0**	**5.4**	**48.6**	**45.9**	**94.6**
TR 1.4-Teachers often purchase materials for activities/labs with their own money.	**2.7**	**2.7**	**32.4**	**51.4**	**10.8**	**5.4**
TR 1.5- There is sufficient access to technology in classrooms for curricular purposes.	**0.0**	**2.7**	**10.8**	**67.6**	**18.9**	**86.5**
TC 1.1- My school has identified challenges to our science, math, engineering and technology program.	**2.7**	**5.4**	**51.4**	**35.1**	**2.7**	**38.9**
TC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	**2.7**	**10.8**	**40.5**	**40.5**	**2.7**	**44.4**
TC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	**5.4**	**10.8**	**54.1**	**24.3**	**2.7**	**27.8**
TC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	**2.7**	**8.1**	**51.4**	**32.4**	**2.7**	**36.1**
TC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	**2.7**	**5.4**	**40.5**	**43.2**	**5.4**	**50.0**

TC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	0.0	10.8	43.2	37.8	2.7	42.9

Table E.4
School Leadership Responses for Fisk High School (n=10)

ITEM	%Strongly Disagree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SLB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	75.0	25.0	0.0	0.0	0.0	100.0
SLB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	12.5	37.5	12.5	37.5	0.0	37.5
SLB 1.3-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	37.5	62.5	0.0	0.0	0.0	100.0
SLB 1.4- Learning should be an orderly process, where students are presented material in a sequence to be remembered.	25.0	25.0	25.0	25.0	0.0	50.0
SLB 1.5- The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	25.0	37.5	37.5	0.0	0.0	62.5
SLB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	12.5	0.0	0.0	62.5	25.0	87.5
SLB 1.7-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	12.5	50.0	25.0	12.5	0.0	62.5

SLB 1.8-Students should build their knowledge upon things they have learned in the past.	12.5	0.0	0.0	87.5	0.0	87.5
SLV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SLV 2.1- To accumulate knowledge about the world around us.	0.0	0.0	0.0	25.0	62.5	100.0
SLV 2.2-To be able to have an educated debate about policies in our community.	12.5	12.5	12.5	37.5	12.5	57.1
SLV 2.3- To understand how concepts are used to assist in their desired way of life.	0.0	0.0	0.0	62.5	25.0	100.0
SLV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	0.0	12.5	25.0	37.5	12.5	57.1
SLV 2.5- To be able to understand the issues in current scientific research.	0.0	12.5	12.5	37.5	25.0	71.4
SLP 1.1- Math teachers work together to develop lessons.	0.0	0.0	0.0	25.0	50.0	100.0
SLP 1.2- Science teachers work together to develop lessons.	0.0	0.0	12.5	37.5	25.0	83.3
SLC 1.1- My school has identified challenges to our science, math, engineering and technology program.	0.0	12.5	50.0	12.5	0.0	16.7
SLC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	0.0	0.0	25.0	50.0	0.0	66.7
SLC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	0.0	25.0	50.0	0.0	0.0	0.0
SLC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	12.5	12.5	12.5	37.5	0.0	50.0

SLC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	**0.0**	**12.5**	**25.0**	**37.5**	**0.0**	**50.0**
SLC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	**0.0**	**0.0**	**25.0**	**50.0**	**0.0**	**66.7**

APPENDIX F: STEM-CAT RESPONSE SUMMARY FOR EVANS HIGH SCHOOL

Table F.1

Parent Responses for Evans High School (n=55)

ITEM	%Strongly Disgree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
PB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**24.5**	**47.2**	**13.2**	**9.4**	**5.7**	**71.7**
PB 1.2-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**0.0**	**0.0**	**5.7**	**45.3**	**50.9**	**94.4**
PB 1.3-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**0.0**	**0.0**	**1.9**	**47.2**	**52.8**	**98.1**
PB 1.4- Students should be exposed to STEM careers during the school day.	**0.0**	**0.0**	**11.3**	**71.7**	**20.8**	**89.1**
PB 1.5- During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**0.0**	**0.0**	**5.7**	**60.4**	**35.8**	**94.4**
PB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**0.0**	**1.9**	**5.7**	**54.7**	**41.5**	**92.7**
PV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
PV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**1.9**	**45.3**	**56.6**	**98.2**
PV 2.2-To be able to have an educated debate about policies in our community.	**3.8**	**1.9**	**17.0**	**39.6**	**41.5**	**78.2**
PV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**3.8**	**7.5**	**39.6**	**50.9**	**88.9**
PV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**1.9**	**5.7**	**13.2**	**28.3**	**54.7**	**80.0**

PV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**0.0**	**7.5**	**52.8**	**43.4**	**92.7**
PR 1.1- Teachers in my school have access to sufficient resources to complete activities/labs.	**1.9**	**32.1**	**45.3**	**18.9**	**3.8**	**22.2**
PR 1.2- Students in my school have access to everyday materials such as pens, pencils and calculators.	**0.0**	**9.4**	**18.9**	**56.6**	**17.0**	**72.2**
PR 1.3- There is sufficient access to technology in classrooms for curricular purposes.	**1.9**	**30.2**	**34.0**	**28.3**	**7.5**	**35.2**

Table F.2
Student Responses for Evans High School (n=53)

ITEM	**%Strongly Disagree**	**% Disagree**	**%Neutral**	**%Agree**	**%Strongly Agree**	**% Positive Response**
SB 1.1- There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**19.2**	**38.5**	**11.5**	**19.2**	**11.5**	**57.7**
SB 1.2- In the past, I have avoided signing up for a difficult STEM course because my peers told me not to.	**15.4**	**38.5**	**23.1**	**13.5**	**9.6**	**53.8**
SB 1.3- 4. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**0.0**	**0.0**	**5.8**	**53.8**	**38.5**	**94.1**
SB 1.4- My counselors encourage me to take advanced STEM courses that might be difficult for me.	**3.8**	**17.3**	**26.9**	**36.5**	**13.5**	**51.0**
SB 1.5- Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering	**0.0**	**1.9**	**9.6**	**34.6**	**51.9**	**88.2**

or technology.						
SB 1.6- Students should build their knowledge upon things they have learned in the past.	**1.9**	**1.9**	**5.8**	**50.0**	**36.5**	**90.0**
SV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SV 2.1- To accumulate knowledge about the world around us.	**0.0**	**1.9**	**7.7**	**32.7**	**57.7**	**90.4**
SV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**3.8**	**11.5**	**32.7**	**50.0**	**84.3**
SV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**23.1**	**25.0**	**51.9**	**76.9**
SV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**1.9**	**13.5**	**30.8**	**53.8**	**84.6**
SV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**3.8**	**15.4**	**28.8**	**50.0**	**80.4**
SR 1.1- Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching	**7.7**	**36.5**	**19.2**	**28.8**	**7.7**	**44.2**
SR 1.2- I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials	**17.3**	**59.6**	**13.5**	**7.7**	**0.0**	**78.4**
SP 1.1- When my science and math teachers are teaching, they talk about how concepts connect to the real world.	**3.8**	**5.8**	**17.3**	**61.5**	**13.5**	**73.6**
SP 1.2- I struggle to understand what my teachers are teaching in science and math because I do not see how it applies to me.	**5.8**	**19.2**	**26.9**	**38.5**	**9.6**	**25.0**
SP 1.3- My science and math lessons begin with an interesting idea that gets me involved in the lessons.	**11.5**	**19.2**	**21.2**	**36.5**	**13.5**	**49.1**

SP 1.4- My math and science teachers ask me what I know about a topic before we begin studying the topic.	**7.7**	**9.6**	**19.2**	**53.8**	**11.5**	**64.2**
SP 1.5- My math and science teachers check with me to make sure I have a good understanding of concepts.	**1.9**	**11.5**	**15.4**	**51.9**	**21.2**	**71.7**
SP 1.6- When solving problems in math class, we solve problems related to real life scenarios.	**7.7**	**9.6**	**21.2**	**44.2**	**19.2**	**62.3**
SP 1.7- My teachers ask me to justify my answers in STEM classes.	**1.9**	**5.8**	**15.4**	**51.9**	**25.0**	**76.9**
SP 1.8- In my math and science classes, I have to explain concepts to other students.	**3.8**	**9.6**	**17.3**	**48.1**	**23.1**	**69.8**
SP 1.9- I have had to defend a product or conclusion in my STEM classes.	**3.8**	**9.6**	**19.2**	**40.4**	**26.9**	**67.3**

Table F.3
Teacher Responses for Evans High School (n=23)

ITEM	%Strongly Disagree	% Disagree	% Neutral	%Agree	%Strongly Agree	% Positive Response
TB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	20.7	58.6	3.4	17.2	0.0	79.3
TB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	0.0	13.8	10.3	69.0	3.4	75.0
TB 1.3-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	0.0	0.0	0.0	48.3	51.7	100.0
TB 1.4-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	0.0	0.0	0.0	44.8	55.2	100.0

TB 1.5-Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'	3.4	27.6	24.1	34.5	10.3	31.0
TB 1.6-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	6.9	58.6	13.8	20.7	0.0	65.5
TB 1.7-Learning should be an orderly process, where students are presented material in a sequence to be remembered.	0.0	48.3	17.2	27.6	6.9	48.3
TB 2.1-The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	3.4	34.5	31.0	20.7	6.9	39.3
TB 2.2-Students should be exposed to STEM careers during the school day.	0.0	0.0	6.9	62.1	27.6	92.9
TB 2.3-During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	0.0	0.0	3.4	58.6	34.5	96.4
TB 2.3-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	0.0	0.0	0.0	69.0	24.1	100.0
TB 2.4-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	10.3	34.5	20.7	24.1	6.9	32.1
TB 2.5-Students should build their knowledge upon things they have learned in the past.	0.0	3.4	0.0	62.1	31.0	96.4
TV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						

TV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**6.9**	**41.4**	**51.7**	**93.1**
TV 2.2-To be able to have an educated debate about policies in our community.	**3.4**	**6.9**	**13.8**	**37.9**	**37.9**	**75.9**
TV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**10.3**	**31.0**	**58.6**	**89.7**
TV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**0.0**	**20.7**	**79.3**	**100.0**
TV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**3.4**	**10.3**	**58.6**	**27.6**	**86.2**
TR 1.1- Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management	**3.4**	**27.6**	**24.1**	**31.0**	**13.8**	**44.8**
TR 1.2- STEM teachers skip labs/activities when they do not have access to the necessary materials.	**0.0**	**24.1**	**24.1**	**48.3**	**3.4**	**24.1**
TR 1.3-Students in my school have access to everyday materials such as pens, pencils and calculators.	**3.4**	**17.2**	**3.4**	**48.3**	**27.6**	**75.9**
TR 1.4-Teachers often purchase materials for activities/labs with their own money.	**0.0**	**3.4**	**6.9**	**37.9**	**51.7**	**3.4**
TR 1.5- There is sufficient access to technology in classrooms for curricular purposes.	**3.4**	**17.2**	**10.3**	**58.6**	**10.3**	**69.0**
TC 1.1- My school has identified challenges to our science, math, engineering and technology program.	**0.0**	**0.0**	**13.8**	**75.9**	**10.3**	**86.2**
TC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	**0.0**	**6.9**	**20.7**	**69.0**	**3.4**	**72.4**
TC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	**0.0**	**17.2**	**37.9**	**41.4**	**3.4**	**44.8**

TC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	0.0	0.0	27.6	62.1	10.3	72.4
TC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	0.0	0.0	24.1	62.1	13.8	75.9
TC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	0.0	6.9	13.8	65.5	13.8	79.3

Table F.4
School Leadership Responses for Evans High School (n=9)

ITEM	%Strongly Disagree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SLB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	11.1	77.8	0.0	0.0	11.1	88.9
SLB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	0.0	33.3	0.0	55.6	11.1	66.7
SLB 1.3-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	11.1	55.6	11.1	11.1	11.1	66.7
SLB 1.4- Learning should be an orderly process, where students are presented material in a sequence to be remembered.	0.0	33.3	11.1	55.6	0.0	33.3
SLB 1.5- The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	0.0	44.4	33.3	11.1	11.1	44.4

SLB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**0.0**	**0.0**	**0.0**	**77.8**	**22.2**	**100.0**
SLB 1.7-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	**0.0**	**22.2**	**44.4**	**22.2**	**11.1**	**22.2**
SLB 1.8-Students should build their knowledge upon things they have learned in the past.	**0.0**	**0.0**	**0.0**	**77.8**	**22.2**	**100.0**
SLV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SLV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**22.2**	**66.7**	**100.0**
SLV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**22.2**	**0.0**	**33.3**	**33.3**	**75.0**
SLV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**0.0**	**33.3**	**55.6**	**100.0**
SLV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**0.0**	**33.3**	**55.6**	**100.0**
SLV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**0.0**	**0.0**	**33.3**	**55.6**	**100.0**
SLP 1.1- Math teachers work together to develop lessons.	**0.0**	**11.1**	**0.0**	**66.7**	**11.1**	**87.5**
SLP 1.2- Science teachers work together to develop lessons.	**0.0**	**11.1**	**0.0**	**66.7**	**11.1**	**87.5**
SLC 1.1- My school has identified challenges to our science, math, engineering and technology program.	**0.0**	**11.1**	**0.0**	**66.7**	**11.1**	**87.5**

SLC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	**0.0**	**11.1**	**11.1**	**55.6**	**11.1**	**75.0**
SLC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	**0.0**	**22.2**	**55.6**	**11.1**	**0.0**	**12.5**
SLC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	**0.0**	**11.1**	**22.2**	**44.4**	**11.1**	**62.5**
SLC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	**0.0**	**11.1**	**11.1**	**55.6**	**11.1**	**75.0**
SLC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	**0.0**	**11.1**	**11.1**	**55.6**	**11.1**	**75.0**

APPENDIX G: STEM-CAT RESPONSE SUMMARY FOR VARITEK HIGH SCHOOL

Table G.1

Parent Responses for Varitek High School (n=40)

ITEM	%Strongly Disgree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
PB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**31.4**	**37.1**	**11.4**	**20.0**	**0.0**	**68.6**
PB 1.2-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**2.9**	**2.9**	**5.7**	**40.0**	**48.6**	**88.6**
PB 1.3-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**2.9**	**0.0**	**2.9**	**48.6**	**45.7**	**94.3**
PB 1.4- Students should be exposed to STEM careers during the school day.	**2.9**	**0.0**	**8.6**	**40.0**	**48.6**	**88.6**
PB 1.5- During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**2.9**	**0.0**	**5.7**	**51.4**	**40.0**	**91.4**
PB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**2.9**	**0.0**	**2.9**	**40.0**	**54.3**	**94.3**
PV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
PV 2.1- To accumulate knowledge about the world around us.	**0.0**	**2.9**	**5.7**	**25.7**	**65.7**	**91.4**
PV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**5.7**	**22.9**	**28.6**	**42.9**	**71.4**
PV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**2.9**	**40.0**	**54.3**	**97.1**

PV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**5.7**	**2.9**	**11.4**	**28.6**	**51.4**	**80.0**
PV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**2.9**	**11.4**	**20.0**	**65.7**	**85.7**
PR 1.1- Teachers in my school have access to sufficient resources to complete activities/labs.	**0.0**	**5.7**	**37.1**	**37.1**	**20.0**	**57.1**
PR 1.2- Students in my school have access to everyday materials such as pens, pencils and calculators.	**0.0**	**2.9**	**20.0**	**42.9**	**34.3**	**77.1**
PR 1.3- There is sufficient access to technology in classrooms for curricular purposes.	**0.0**	**2.9**	**17.1**	**51.4**	**28.6**	**80.0**

Table G.2
Student Responses for Varitek High School (n=79)

ITEM	%Strongly Disagree	% Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SB 1.1- There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**7.0**	**21.1**	**22.5**	**45.1**	**4.2**	**28.2**
SB 1.2- In the past, I have avoided signing up for a difficult STEM course because my peers told me not to.	**35.2**	**35.2**	**19.7**	**9.9**	**0.0**	**70.4**
SB 1.3- 4. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**1.4**	**5.6**	**12.7**	**47.9**	**32.4**	**80.3**
SB 1.4- My counselors encourage me to take advanced STEM courses that might be difficult for me.	**4.2**	**19.7**	**33.8**	**33.8**	**7.0**	**41.4**
SB 1.5- Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**0.0**	**5.6**	**9.9**	**56.3**	**28.2**	**84.5**

SB 1.6- Students should build their knowledge upon things they have learned in the past.	**1.4**	**2.8**	**8.5**	**60.6**	**26.8**	**87.3**
SV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SV 2.1- To accumulate knowledge about the world around us.	**1.4**	**2.8**	**21.1**	**36.6**	**38.0**	**74.6**
SV 2.2-To be able to have an educated debate about policies in our community.	**2.8**	**9.9**	**35.2**	**29.6**	**22.5**	**52.1**
SV 2.3- To understand how concepts are used to assist in their desired way of life.	**1.4**	**2.8**	**16.9**	**45.1**	**33.8**	**78.9**
SV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**2.8**	**1.4**	**18.3**	**35.2**	**42.3**	**77.5**
SV 2.5- To be able to understand the issues in current scientific research.	**1.4**	**9.9**	**32.4**	**31.0**	**25.4**	**56.3**
SR 1.1- Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching	**8.5**	**25.4**	**36.6**	**23.9**	**4.2**	**34.3**
SR 1.2- I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials	**12.7**	**49.3**	**25.4**	**12.7**	**0.0**	**62.0**
SP 1.1- When my science and math teachers are teaching, they talk about how concepts connect to the real world.	**11.3**	**15.5**	**23.9**	**35.2**	**12.7**	**48.6**
SP 1.2- I struggle to understand what my teachers are teaching in science and math because I do not see how it applies to me.	**8.5**	**28.2**	**19.7**	**32.4**	**9.9**	**37.1**
SP 1.3- My science and math lessons begin with an interesting idea that gets me involved in the lessons.	**15.5**	**26.8**	**36.6**	**16.9**	**2.8**	**20.0**
SP 1.4- My math and science teachers ask me what I know about a topic before we begin studying the topic.	**14.1**	**14.1**	**23.9**	**39.4**	**7.0**	**47.1**

SP 1.5- My math and science teachers check with me to make sure I have a good understanding of concepts.	**7.0**	**8.5**	**35.2**	**42.3**	**4.2**	**47.8**
SP 1.6- When solving problems in math class, we solve problems related to real life scenarios.	**19.7**	**22.5**	**21.1**	**31.0**	**4.2**	**35.7**
SP 1.7- My teachers ask me to justify my answers in STEM classes.	**8.5**	**14.1**	**36.6**	**32.4**	**7.0**	**40.0**
SP 1.8- In my math and science classes, I have to explain concepts to other students.	**4.2**	**21.1**	**32.4**	**36.6**	**2.8**	**40.6**
SP 1.9- I have had to defend a product or conclusion in my STEM classes.	**11.3**	**11.3**	**45.1**	**29.6**	**1.4**	**31.4**

Table G.3
Teacher Responses for Varitek High School (n=41)

ITEM	%Strongly Disagree	% Disagree	% Neutral	%Agree	%Strongly Agree	% Positive Response
TB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	31.6	57.9	5.3	5.3	0.0	89.5
TB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	2.6	13.2	23.7	52.6	7.9	60.5
TB 1.3-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	0.0	0.0	5.3	23.7	73.7	94.9
TB 1.4-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	0.0	0.0	2.6	34.2	65.8	97.4
TB 1.5-Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'	7.9	36.8	13.2	36.8	7.9	43.6

TB 1.6-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	**13.2**	**55.3**	**15.8**	**15.8**	**2.6**	**66.7**
TB 1.7-Learning should be an orderly process, where students are presented material in a sequence to be remembered.	**7.9**	**47.4**	**21.1**	**23.7**	**2.6**	**53.8**
TB 2.1-The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	**15.8**	**60.5**	**10.5**	**15.8**	**0.0**	**74.4**
TB 2.2-Students should be exposed to STEM careers during the school day.	**0.0**	**5.3**	**10.5**	**60.5**	**23.7**	**84.2**
TB 2.3-During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**0.0**	**0.0**	**2.6**	**47.4**	**50.0**	**97.4**
TB 2.3-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**0.0**	**0.0**	**5.3**	**52.6**	**44.7**	**94.9**
TB 2.4-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	**5.3**	**39.5**	**28.9**	**23.7**	**5.3**	**28.2**
TB 2.5-Students should build their knowledge upon things they have learned in the past.	**0.0**	**2.6**	**2.6**	**60.5**	**36.8**	**94.9**
TV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
TV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**23.7**	**76.3**	**100.0**
TV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**2.6**	**21.1**	**36.8**	**36.8**	**75.7**
TV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**2.6**	**34.2**	**63.2**	**97.4**

TV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**10.5**	**21.1**	**68.4**	**89.5**
TV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**0.0**	**2.6**	**42.1**	**55.3**	**97.4**
TR 1.1- Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management	**5.3**	**21.1**	**34.2**	**36.8**	**5.3**	**41.0**
TR 1.2- STEM teachers skip labs/activities when they do not have access to the necessary materials.	**2.6**	**44.7**	**28.9**	**23.7**	**2.6**	**46.2**
TR 1.3-Students in my school have access to everyday materials such as pens, pencils and calculators.	**0.0**	**5.3**	**2.6**	**36.8**	**57.9**	**92.3**
TR 1.4-Teachers often purchase materials for activities/labs with their own money.	**0.0**	**2.6**	**15.8**	**31.6**	**52.6**	**2.6**
TR 1.5- There is sufficient access to technology in classrooms for curricular purposes.	**0.0**	**2.6**	**15.8**	**36.8**	**47.4**	**82.1**
TC 1.1- My school has identified challenges to our science, math, engineering and technology program.	**2.6**	**7.9**	**21.1**	**52.6**	**18.4**	**69.2**
TC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	**2.6**	**2.6**	**18.4**	**57.9**	**18.4**	**76.3**
TC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	**0.0**	**7.9**	**34.2**	**42.1**	**15.8**	**57.9**
TC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	**0.0**	**5.3**	**10.5**	**55.3**	**31.6**	**84.6**
TC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	**0.0**	**5.3**	**23.7**	**42.1**	**31.6**	**71.8**

TC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	2.6	5.3	15.8	47.4	31.6	76.9

Table G.4
School Leadership Responses for Varitek High School (n=8)

ITEM	%Strongly Disagree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SLB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	50.0	33.3	16.7	0.0	0.0	83.3
SLB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	0.0	33.3	33.3	33.3	0.0	33.3
SLB 1.3-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	33.3	66.7	0.0	0.0	0.0	100.0
SLB 1.4- Learning should be an orderly process, where students are presented material in a sequence to be remembered.	16.7	50.0	16.7	16.7	0.0	66.7
SLB 1.5- The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	0.0	83.3	16.7	0.0	0.0	83.3
SLB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind	0.0	0.0	0.0	66.7	33.3	100.0

necessary to do science and mathematics.						
SLB 1.7-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	**16.7**	**50.0**	**16.7**	**16.7**	**0.0**	**66.7**
SLB 1.8-Students should build their knowledge upon things they have learned in the past.	**0.0**	**0.0**	**0.0**	**83.3**	**16.7**	**100.0**
SLV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SLV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**100.0**
SLV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**0.0**	**0.0**	**50.0**	**50.0**	**100.0**
SLV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**0.0**	**16.7**	**83.3**	**100.0**
SLV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**100.0**
SLV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**0.0**	**0.0**	**50.0**	**50.0**	**100.0**
SLP 1.1- Math teachers work together to develop lessons.	**0.0**	**0.0**	**33.3**	**16.7**	**50.0**	**66.7**
SLP 1.2- Science teachers work together to develop lessons.	**0.0**	**0.0**	**33.3**	**16.7**	**50.0**	**66.7**

SLC 1.1- My school has identified challenges to our science, math, engineering and technology program.	**0.0**	**0.0**	**33.3**	**66.7**	**0.0**	**66.7**
SLC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**33.3**	**16.7**	**50.0**	**66.7**
SLC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	**0.0**	**16.7**	**50.0**	**16.7**	**16.7**	**33.3**
SLC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	**0.0**	**0.0**	**16.7**	**50.0**	**33.3**	**83.3**
SLC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**33.3**	**50.0**	**16.7**	**66.7**
SLC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	**0.0**	**0.0**	**50.0**	**16.7**	**33.3**	**50.0**

APPENDIX H: STEM-CAT RESPONSE SUMMARY FOR BOGGS HIGH SCHOOL

Table H.1

Parent Responses for Boggs High School (n=5)

ITEM	%Strongly Disgree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
PB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**40.0**	**40.0**	**0.0**	**20.0**	**0.0**	**80.0**
PB 1.2-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**0.0**	**0.0**	**0.0**	**20.0**	**80.0**	**100.0**
PB 1.3-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**0.0**	**0.0**	**0.0**	**40.0**	**60.0**	**100.0**
PB 1.4- Students should be exposed to STEM careers during the school day.	**0.0**	**0.0**	**0.0**	**40.0**	**60.0**	**100.0**
PB 1.5- During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**0.0**	**0.0**	**0.0**	**40.0**	**60.0**	**100.0**
PB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**0.0**	**0.0**	**0.0**	**40.0**	**60.0**	**100.0**
PV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
PV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**100.0**
PV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**0.0**	**0.0**	**0.0**	**100.0**	**100.0**
PV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**0.0**	**20.0**	**80.0**	**100.0**
PV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**0.0**	**20.0**	**80.0**	**100.0**
PV 2.5- To be able to understand the issues in current scientific	**0.0**	**0.0**	**0.0**	**20.0**	**80.0**	**100.0**

research.						
PR 1.1- Teachers in my school have access to sufficient resources to complete activities/labs.	**0.0**	**0.0**	**20.0**	**80.0**	**0.0**	**80.0**
PR 1.2- Students in my school have access to everyday materials such as pens, pencils and calculators.	**0.0**	**0.0**	**20.0**	**40.0**	**40.0**	**80.0**
PR 1.3- There is sufficient access to technology in classrooms for curricular purposes.	**0.0**	**20.0**	**40.0**	**40.0**	**0.0**	**40.0**

Table H.2
Student Responses for Boggs High School (n=48)

ITEM	%Strongly Disagree	% Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SB 1.1- There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**16.7**	**16.7**	**37.5**	**22.9**	**6.3**	**33.3**
SB 1.2- In the past, I have avoided signing up for a difficult STEM course because my peers told me not to.	**22.9**	**27.1**	**27.1**	**20.8**	**2.1**	**50.0**
SB 1.3- 4. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**4.2**	**4.2**	**10.4**	**33.3**	**45.8**	**80.9**
SB 1.4- My counselors encourage me to take advanced STEM courses that might be difficult for me.	**8.3**	**14.6**	**33.3**	**25.0**	**16.7**	**42.6**
SB 1.5- Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**4.2**	**2.1**	**12.5**	**37.5**	**41.7**	**80.9**
SB 1.6- Students should build their knowledge upon things they have learned in the past.	**0.0**	**4.2**	**16.7**	**45.8**	**31.3**	**78.7**

SV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**18.8**	**33.3**	**52.1**	**82.0**
SV 2.2-To be able to have an educated debate about policies in our community.	**2.1**	**0.0**	**39.6**	**35.4**	**27.1**	**60.0**
SV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**2.1**	**29.2**	**31.3**	**41.7**	**70.0**
SV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**2.1**	**8.3**	**18.8**	**20.8**	**54.2**	**72.0**
SV 2.5- To be able to understand the issues in current scientific research.	**4.2**	**6.3**	**16.7**	**33.3**	**43.8**	**74.0**
SR 1.1- Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching	**2.1**	**18.8**	**31.3**	**37.5**	**16.7**	**19.6**
SR 1.2- I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials	**14.6**	**33.3**	**33.3**	**16.7**	**10.4**	**44.2**
SP 1.1- When my science and math teachers are teaching, they talk about how concepts connect to the real world.	**0.0**	**12.5**	**29.2**	**47.9**	**10.4**	**58.3**
SP 1.2- I struggle to understand what my teachers are teaching in science and math because I do not see how it applies to me.	**4.2**	**27.1**	**27.1**	**33.3**	**8.3**	**31.3**
SP 1.3- My science and math lessons begin with an interesting idea that gets me involved in the lessons.	**25.0**	**12.5**	**35.4**	**20.8**	**4.2**	**25.5**
SP 1.4- My math and science teachers ask me what I know about a topic before we begin studying the topic.	**12.5**	**12.5**	**20.8**	**41.7**	**12.5**	**54.2**
SP 1.5- My math and science teachers check with me to make sure I have a good understanding of concepts.	**6.3**	**27.1**	**22.9**	**31.3**	**10.4**	**42.6**

SP 1.6- When solving problems in math class, we solve problems related to real life scenarios.	**2.1**	**14.6**	**35.4**	**35.4**	**10.4**	**46.8**
SP 1.7- My teachers ask me to justify my answers in STEM classes.	**2.1**	**12.5**	**45.8**	**29.2**	**10.4**	**39.6**
SP 1.8- In my math and science classes, I have to explain concepts to other students.	**8.3**	**14.6**	**33.3**	**37.5**	**6.3**	**43.8**
SP 1.9- I have had to defend a product or conclusion in my STEM classes.	**8.3**	**16.7**	**43.8**	**25.0**	**6.3**	**31.3**

Table H.3
Teacher Responses for Boggs High School (n=23)

ITEM	%Strongly Disagree	% Disagree	% Neutral	%Agree	%Strongly Agree	% Positive Response
TB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**34.8**	**21.7**	**17.4**	**21.7**	**4.3**	**56.5**
TB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	**4.3**	**8.7**	**13.0**	**60.9**	**13.0**	**73.9**
TB 1.3-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**0.0**	**4.3**	**4.3**	**26.1**	**65.2**	**91.3**
TB 1.4-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**0.0**	**0.0**	**0.0**	**43.5**	**56.5**	**100.0**
TB 1.5-Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'	**13.0**	**21.7**	**21.7**	**30.4**	**13.0**	**34.8**
TB 1.6-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a	**30.4**	**34.8**	**17.4**	**8.7**	**8.7**	**65.2**

problem.						
TB 1.7-Learning should be an orderly process, where students are presented material in a sequence to be remembered.	17.4	21.7	26.1	30.4	4.3	39.1
TB 2.1-The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	13.0	43.5	13.0	21.7	4.3	59.1
TB 2.2-Students should be exposed to STEM careers during the school day.	0.0	0.0	8.7	60.9	26.1	90.9
TB 2.3-During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	0.0	0.0	0.0	52.2	39.1	100.0
TB 2.3-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	0.0	0.0	4.3	43.5	47.8	95.5
TB 2.4-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	0.0	43.5	13.0	21.7	17.4	40.9
TB 2.5-Students should build their knowledge upon things they have learned in the past.	0.0	0.0	13.0	60.9	21.7	86.4
TV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
TV 2.1- To accumulate knowledge about the world around us.	0.0	0.0	0.0	13.0	82.6	100.0
TV 2.2-To be able to have an educated debate about policies in our community.	0.0	0.0	8.7	39.1	47.8	90.9
TV 2.3- To understand how concepts are used to assist in their desired way of life.	0.0	0.0	8.7	47.8	39.1	90.9

TV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	0.0	8.7	0.0	17.4	69.6	90.9
TV 2.5- To be able to understand the issues in current scientific research.	0.0	8.7	4.3	30.4	52.2	86.4
TR 1.1- Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management	17.4	21.7	17.4	13.0	26.1	40.9
TR 1.2- STEM teachers skip labs/activities when they do not have access to the necessary materials.	4.3	8.7	34.8	21.7	26.1	13.6
TR 1.3-Students in my school have access to everyday materials such as pens, pencils and calculators.	4.3	26.1	4.3	30.4	30.4	63.6
TR 1.4-Teachers often purchase materials for activities/labs with their own money.	0.0	0.0	8.7	34.8	52.2	0.0
TR 1.5- There is sufficient access to technology in classrooms for curricular purposes.	17.4	26.1	13.0	26.1	13.0	40.9
TC 1.1- My school has identified challenges to our science, math, engineering and technology program.	4.3	21.7	34.8	26.1	4.3	33.3
TC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	4.3	30.4	26.1	26.1	4.3	33.3
TC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	8.7	26.1	30.4	21.7	4.3	28.6
TC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	4.3	26.1	34.8	21.7	4.3	28.6
TC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	4.3	21.7	34.8	26.1	4.3	33.3

TC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	4.3	13.0	34.8	26.1	13.0	42.9

Table H.4
School Leadership Responses for Boggs High School (n=2)

ITEM	%Strongly Disagree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SLB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	100.0	0.0	0.0	0.0	0.0	100.0
SLB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	0.0	50.0	50.0	0.0	0.0	0.0
SLB 1.3-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	50.0	50.0	0.0	0.0	0.0	100.0
SLB 1.4- Learning should be an orderly process, where students are presented material in a sequence to be remembered.	0.0	100.0	0.0	0.0	0.0	100.0
SLB 1.5- The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	0.0	100.0	0.0	0.0	0.0	100.0
SLB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	0.0	0.0	0.0	100.0	0.0	100.0
SLB 1.7-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	0.0	100.0	0.0	0.0	0.0	100.0
SLB 1.8-Students should build their knowledge upon things they have learned in the past.	0.0	0.0	0.0	50.0	50.0	100.0

SLV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SLV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**50.0**	**50.0**	**100.0**
SLV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**0.0**	**50.0**	**50.0**	**100.0**
SLV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**0.0**	**50.0**	**50.0**	**100.0**
SLV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**50.0**	**0.0**	**50.0**	**0.0**	**50.0**
SLP 1.1- Math teachers work together to develop lessons.	**0.0**	**0.0**	**50.0**	**50.0**	**0.0**	**50.0**
SLP 1.2- Science teachers work together to develop lessons.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLC 1.1- My school has identified challenges to our science, math, engineering and technology program.	**0.0**	**0.0**	**50.0**	**50.0**	**0.0**	**50.0**
SLC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	**0.0**	**50.0**	**0.0**	**50.0**	**0.0**	**50.0**
SLC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	**0.0**	**50.0**	**0.0**	**50.0**	**0.0**	**50.0**
SLC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**

SLC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	**0.0**	**0.0**	**50.0**	**50.0**	**0.0**	**50.0**

APPENDIX I: STEM-CAT RESPONSE SUMMARY FOR WILLIAMS HIGH SCHOOL

Table I.1

Parent Responses for Williams High School (n=17)

ITEM	%Strongly Disgree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
PB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**41.2**	**23.5**	**0.0**	**29.4**	**5.9**	**64.7**
PB 1.2-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**0.0**	**0.0**	**0.0**	**35.3**	**64.7**	**100.0**
PB 1.3-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**0.0**	**0.0**	**0.0**	**52.9**	**47.1**	**100.0**
PB 1.4- Students should be exposed to STEM careers during the school day.	**0.0**	**0.0**	**23.5**	**47.1**	**29.4**	**76.5**
PB 1.5- During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**0.0**	**0.0**	**5.9**	**52.9**	**41.2**	**94.1**
PB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**0.0**	**0.0**	**0.0**	**58.8**	**35.3**	**100.0**
PV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
PV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**29.4**	**70.6**	**100.0**
PV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**0.0**	**0.0**	**52.9**	**47.1**	**100.0**
PV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**0.0**	**47.1**	**52.9**	**100.0**
PV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**0.0**	**29.4**	**70.6**	**100.0**
PV 2.5- To be able to understand the issues in current scientific	**0.0**	**0.0**	**0.0**	**52.9**	**47.1**	**100.0**

research.						
PR 1.1- Teachers in my school have access to sufficient resources to complete activities/labs.	**11.8**	**41.2**	**17.6**	**29.4**	**0.0**	**29.4**
PR 1.2- Students in my school have access to everyday materials such as pens, pencils and calculators.	**0.0**	**5.9**	**35.3**	**41.2**	**17.6**	**58.8**
PR 1.3- There is sufficient access to technology in classrooms for curricular purposes.	**23.5**	**29.4**	**11.8**	**35.3**	**0.0**	**35.3**

Table I.2
Student Responses for Williams High School (n=36)

ITEM	%Strongly Disagree	% Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SB 1.1- There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**19.2**	**30.8**	**19.2**	**23.1**	**7.7**	**50.0**
SB 1.2- In the past, I have avoided signing up for a difficult STEM course because my peers told me not to.	**23.1**	**42.3**	**11.5**	**19.2**	**3.8**	**65.4**
SB 1.3- 4. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**0.0**	**3.8**	**3.8**	**46.2**	**46.2**	**92.3**
SB 1.4- My counselors encourage me to take advanced STEM courses that might be difficult for me.	**11.5**	**15.4**	**23.1**	**38.5**	**7.7**	**48.0**
SB 1.5- Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**0.0**	**3.8**	**3.8**	**42.3**	**46.2**	**92.0**
SB 1.6- Students should build their knowledge upon things they have learned in the past.	**0.0**	**0.0**	**15.4**	**57.7**	**26.9**	**84.6**

SV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**15.4**	**26.9**	**69.2**	**86.2**
SV 2.2-To be able to have an educated debate about policies in our community.	**3.8**	**3.8**	**34.6**	**50.0**	**19.2**	**62.1**
SV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**3.8**	**23.1**	**50.0**	**34.6**	**75.9**
SV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**3.8**	**0.0**	**7.7**	**50.0**	**50.0**	**89.7**
SV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**3.8**	**23.1**	**34.6**	**50.0**	**75.9**
SR 1.1- Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching	**19.2**	**34.6**	**26.9**	**23.1**	**7.7**	**48.3**
SR 1.2- I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials	**38.5**	**50.0**	**15.4**	**0.0**	**7.7**	**79.3**
SP 1.1- When my science and math teachers are teaching, they talk about how concepts connect to the real world.	**15.4**	**30.8**	**38.5**	**23.1**	**3.8**	**24.1**
SP 1.2- I struggle to understand what my teachers are teaching in science and math because I do not see how it applies to me.	**15.4**	**19.2**	**38.5**	**19.2**	**19.2**	**31.0**
SP 1.3- My science and math lessons begin with an interesting idea that gets me involved in the lessons.	**23.1**	**42.3**	**23.1**	**19.2**	**3.8**	**20.7**
SP 1.4- My math and science teachers ask me what I know about a topic before we begin studying the topic.	**7.7**	**23.1**	**26.9**	**30.8**	**23.1**	**48.3**
SP 1.5- My math and science teachers check with me to make sure I have a good understanding of concepts.	**7.7**	**19.2**	**34.6**	**26.9**	**23.1**	**44.8**

SP 1.6- When solving problems in math class, we solve problems related to real life scenarios.	**30.8**	**19.2**	**38.5**	**15.4**	**7.7**	**20.7**
SP 1.7- My teachers ask me to justify my answers in STEM classes.	**23.1**	**23.1**	**15.4**	**38.5**	**11.5**	**44.8**
SP 1.8- In my math and science classes, I have to explain concepts to other students.	**15.4**	**19.2**	**11.5**	**46.2**	**19.2**	**58.6**
SP 1.9- I have had to defend a product or conclusion in my STEM classes.	**15.4**	**23.1**	**23.1**	**38.5**	**11.5**	**44.8**

Table I.3
Teacher Responses for Williams High School (n=23)

ITEM	%Strongly Disagree	% Disagree	% Neutral	%Agree	%Strongly Agree	% Positive Response
TB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	36.4	36.4	13.6	4.5	9.1	72.7
TB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	0.0	27.3	13.6	40.9	18.2	59.1
TB 1.3-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	0.0	0.0	0.0	59.1	40.9	100.0
TB 1.4-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	0.0	0.0	0.0	45.5	54.5	100.0
TB 1.5-Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'	13.6	22.7	22.7	18.2	22.7	36.4
TB 1.6-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	31.8	45.5	4.5	18.2	0.0	77.3

TB 1.7-Learning should be an orderly process, where students are presented material in a sequence to be remembered.	**27.3**	**13.6**	**22.7**	**22.7**	**13.6**	**40.9**
TB 2.1-The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	**9.1**	**22.7**	**27.3**	**31.8**	**9.1**	**31.8**
TB 2.2-Students should be exposed to STEM careers during the school day.	**0.0**	**0.0**	**27.3**	**45.5**	**27.3**	**72.7**
TB 2.3-During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**0.0**	**0.0**	**4.5**	**45.5**	**50.0**	**95.5**
TB 2.3-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**0.0**	**0.0**	**9.1**	**40.9**	**50.0**	**90.9**
TB 2.4-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	**4.5**	**50.0**	**18.2**	**22.7**	**4.5**	**27.3**
TB 2.5-Students should build their knowledge upon things they have learned in the past.	**0.0**	**0.0**	**13.6**	**63.6**	**22.7**	**86.4**
TV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
TV 2.1- To accumulate knowledge about the world around us.	**4.5**	**0.0**	**0.0**	**31.8**	**63.6**	**95.5**
TV 2.2-To be able to have an educated debate about policies in our community.	**4.5**	**4.5**	**4.5**	**27.3**	**59.1**	**86.4**
TV 2.3- To understand how concepts are used to assist in their desired way of life.	**4.5**	**0.0**	**0.0**	**45.5**	**50.0**	**95.5**
TV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**4.5**	**0.0**	**4.5**	**18.2**	**72.7**	**90.9**
TV 2.5- To be able to understand the issues in current scientific research.	**4.5**	**0.0**	**9.1**	**27.3**	**59.1**	**86.4**

TR 1.1- Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management	9.1	27.3	22.7	27.3	13.6	40.9
TR 1.2- STEM teachers skip labs/activities when they do not have access to the necessary materials.	22.7	0.0	27.3	40.9	9.1	22.7
TR 1.3-Students in my school have access to everyday materials such as pens, pencils and calculators.	4.5	0.0	22.7	40.9	31.8	72.7
TR 1.4-Teachers often purchase materials for activities/labs with their own money.	4.5	4.5	27.3	27.3	36.4	9.1
TR 1.5- There is sufficient access to technology in classrooms for curricular purposes.	18.2	59.1	4.5	18.2	0.0	18.2
TC 1.1- My school has identified challenges to our science, math, engineering and technology program.	9.1	13.6	36.4	27.3	13.6	40.9
TC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	9.1	18.2	31.8	31.8	9.1	40.9
TC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	13.6	31.8	36.4	13.6	4.5	18.2
TC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	13.6	27.3	27.3	27.3	4.5	31.8
TC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	9.1	22.7	36.4	22.7	9.1	31.8
TC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	4.5	18.2	45.5	18.2	13.6	31.8

Table I.4
School Leadership Responses for Williams High School (n=4)

ITEM	%Strongly Disagree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SLB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	100.0	0.0	0.0	0.0	0.0	100.0
SLB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	0.0	0.0	33.3	33.3	33.3	66.7
SLB 1.3-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	0.0	66.7	33.3	0.0	0.0	66.7
SLB 1.4- Learning should be an orderly process, where students are presented material in a sequence to be remembered.	0.0	33.3	33.3	0.0	0.0	50.0
SLB 1.5- The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	0.0	33.3	33.3	0.0	0.0	50.0
SLB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	0.0	0.0	33.3	33.3	0.0	50.0
SLB 1.7-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	0.0	0.0	66.7	0.0	0.0	0.0
SLB 1.8-Students should build their knowledge upon things they have learned in the past.	0.0	0.0	0.0	66.7	0.0	100.0
SLV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						

SLV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**0.0**	**66.7**	**100.0**
SLV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**0.0**	**0.0**	**0.0**	**66.7**	**100.0**
SLV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**0.0**	**0.0**	**66.7**	**100.0**
SLV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**0.0**	**33.3**	**33.3**	**100.0**
SLV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**0.0**	**0.0**	**33.3**	**33.3**	**100.0**
SLP 1.1- Math teachers work together to develop lessons.	**0.0**	**33.3**	**0.0**	**33.3**	**0.0**	**50.0**
SLP 1.2- Science teachers work together to develop lessons.	**0.0**	**33.3**	**0.0**	**33.3**	**0.0**	**50.0**
SLC 1.1- My school has identified challenges to our science, math, engineering and technology program.	**0.0**	**0.0**	**33.3**	**33.3**	**0.0**	**50.0**
SLC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**33.3**	**33.3**	**0.0**	**50.0**
SLC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	**0.0**	**33.3**	**0.0**	**33.3**	**0.0**	**50.0**
SLC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	**0.0**	**0.0**	**33.3**	**33.3**	**0.0**	**50.0**
SLC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**33.3**	**33.3**	**0.0**	**50.0**
SLC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for	**0.0**	**0.0**	**33.3**	**33.3**	**0.0**	**50.0**

continuous improvement.			

APPENDIX J: STEM-CAT RESPONSE SUMMARY FOR ORTIZ HIGH SCHOOL

Table J.1

Parent Responses for Ortiz High School (n=39)

ITEM	%Strongly Disgree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
PB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**9.1**	**39.4**	**12.1**	**36.4**	**3.0**	**48.5**
PB 1.2-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**6.1**	**0.0**	**6.1**	**57.6**	**30.3**	**87.9**
PB 1.3-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**3.0**	**3.0**	**0.0**	**60.6**	**33.3**	**93.9**
PB 1.4- Students should be exposed to STEM careers during the school day.	**3.0**	**6.1**	**9.1**	**63.6**	**18.2**	**81.8**
PB 1.5- During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**3.0**	**6.1**	**6.1**	**57.6**	**30.3**	**85.3**
PB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**3.0**	**3.0**	**3.0**	**48.5**	**42.4**	**90.9**
PV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
PV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**3.0**	**33.3**	**66.7**	**97.1**
PV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**3.0**	**15.2**	**48.5**	**36.4**	**82.4**
PV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**12.1**	**42.4**	**48.5**	**88.2**

PV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**3.0**	**0.0**	**6.1**	**27.3**	**66.7**	**91.2**
PV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**0.0**	**6.1**	**54.5**	**42.4**	**94.1**
PR 1.1- Teachers in my school have access to sufficient resources to complete activities/labs.	**0.0**	**6.1**	**39.4**	**57.6**	**0.0**	**55.9**
PR 1.2- Students in my school have access to everyday materials such as pens, pencils and calculators.	**0.0**	**6.1**	**21.2**	**51.5**	**24.2**	**73.5**
PR 1.3- There is sufficient access to technology in classrooms for curricular purposes.	**0.0**	**12.1**	**27.3**	**60.6**	**3.0**	**61.8**

Table J.2
Student Responses for Ortiz High School (n=66)

ITEM	**%Strongly Disagree**	**% Disagree**	**%Neutral**	**%Agree**	**%Strongly Agree**	**% Positive Response**
SB 1.1- There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**8.2**	**30.6**	**24.5**	**34.7**	**2.0**	**38.8**
SB 1.2- In the past, I have avoided signing up for a difficult STEM course because my peers told me not to.	**22.4**	**40.8**	**8.2**	**18.4**	**10.2**	**63.3**
SB 1.3- 4. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**2.0**	**0.0**	**14.3**	**44.9**	**38.8**	**83.7**
SB 1.4- My counselors encourage me to take advanced STEM courses that might be difficult for me.	**4.1**	**12.2**	**26.5**	**40.8**	**16.3**	**57.1**
SB 1.5- Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**2.0**	**2.0**	**14.3**	**51.0**	**30.6**	**81.6**
SB 1.6- Students should build their knowledge upon things they have learned in the past.	**2.0**	**2.0**	**16.3**	**40.8**	**36.7**	**79.2**

SV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**16.3**	**55.1**	**32.7**	**84.3**
SV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**2.0**	**34.7**	**42.9**	**24.5**	**64.7**
SV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**2.0**	**26.5**	**53.1**	**22.4**	**72.5**
SV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**2.0**	**4.1**	**18.4**	**36.7**	**42.9**	**76.5**
SV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**8.2**	**24.5**	**51.0**	**18.4**	**68.0**
SR 1.1- Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching	**16.3**	**36.7**	**28.6**	**16.3**	**4.1**	**52.0**
SR 1.2- I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials	**30.6**	**34.7**	**20.4**	**12.2**	**6.1**	**62.7**
SP 1.1- When my science and math teachers are teaching, they talk about how concepts connect to the real world.	**6.1**	**14.3**	**28.6**	**36.7**	**16.3**	**52.0**
SP 1.2- I struggle to understand what my teachers are teaching in science and math because I do not see how it applies to me.	**12.2**	**28.6**	**28.6**	**22.4**	**10.2**	**40.0**
SP 1.3- My science and math lessons begin with an interesting idea that gets me involved in the lessons.	**22.4**	**20.4**	**40.8**	**12.2**	**6.1**	**18.0**
SP 1.4- My math and science teachers ask me what I know about a topic before we begin studying the topic.	**8.2**	**14.3**	**26.5**	**38.8**	**14.3**	**52.0**
SP 1.5- My math and science teachers check with me to make sure I have a good understanding of concepts.	**10.2**	**18.4**	**26.5**	**36.7**	**10.2**	**46.0**

SP 1.6- When solving problems in math class, we solve problems related to real life scenarios.	**12.2**	**12.2**	**26.5**	**38.8**	**12.2**	**50.0**
SP 1.7- My teachers ask me to justify my answers in STEM classes.	**2.0**	**10.2**	**36.7**	**38.8**	**14.3**	**52.0**
SP 1.8- In my math and science classes, I have to explain concepts to other students.	**8.2**	**10.2**	**36.7**	**30.6**	**16.3**	**46.0**
SP 1.9- I have had to defend a product or conclusion in my STEM classes.	**8.2**	**12.2**	**40.8**	**30.6**	**10.2**	**40.0**

Table J.3

Teacher Responses for Ortiz High School (n=39)

ITEM	%Strongly Disagree	% Disagree	% Neutral	%Agree	%Strongly Agree	% Positive Response
TB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	30.8	46.2	5.1	15.4	2.6	76.9
TB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	5.1	17.9	15.4	46.2	12.8	60.5
TB 1.3-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	0.0	0.0	5.1	38.5	56.4	94.9
TB 1.4-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	0.0	0.0	0.0	51.3	48.7	100.0
TB 1.5-Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and ends with 'reporting the results.'	12.8	25.6	12.8	33.3	15.4	38.5

TB 1.6-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	23.1	53.8	12.8	7.7	2.6	76.9
TB 1.7-Learning should be an orderly process, where students are presented material in a sequence to be remembered.	15.4	15.4	30.8	33.3	5.1	30.8
TB 2.1-The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	17.9	43.6	15.4	15.4	5.1	63.2
TB 2.2-Students should be exposed to STEM careers during the school day.	0.0	2.6	7.7	56.4	30.8	89.5
TB 2.3-During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	0.0	0.0	2.6	48.7	46.2	97.4
TB 2.3-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	0.0	0.0	0.0	48.7	48.7	100.0
TB 2.4-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	10.3	41.0	15.4	20.5	10.3	31.6
TB 2.5-Students should build their knowledge upon things they have learned in the past.	0.0	0.0	5.1	74.4	17.9	94.7
TV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
TV 2.1- To accumulate knowledge about the world around us.	0.0	2.6	2.6	12.8	79.5	94.7
TV 2.2-To be able to have an educated debate about policies in our community.	0.0	2.6	17.9	33.3	41.0	78.4

TV 2.3- To understand how concepts are used to assist in their desired way of life.	0.0	2.6	2.6	33.3	56.4	94.6
TV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	0.0	0.0	2.6	17.9	74.4	97.3
TV 2.5- To be able to understand the issues in current scientific research.	0.0	10.3	12.8	30.8	41.0	75.7
TR 1.1- Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management	10.3	30.8	28.2	20.5	7.7	28.9
TR 1.2- STEM teachers skip labs/activities when they do not have access to the necessary materials.	5.1	7.7	48.7	28.2	7.7	13.2
TR 1.3-Students in my school have access to everyday materials such as pens, pencils and calculators.	5.1	0.0	0.0	53.8	38.5	94.7
TR 1.4-Teachers often purchase materials for activities/labs with their own money.	0.0	2.6	5.1	43.6	46.2	2.6
TR 1.5- There is sufficient access to technology in classrooms for curricular purposes.	15.4	48.7	5.1	23.1	5.1	28.9
TC 1.1- My school has identified challenges to our science, math, engineering and technology program.	0.0	12.8	30.8	46.2	7.7	55.3
TC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	2.6	10.3	30.8	43.6	10.3	55.3
TC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	10.3	25.6	33.3	17.9	7.7	27.0
TC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	2.6	10.3	48.7	25.6	5.1	33.3

TC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	5.1	7.7	38.5	41.0	2.6	45.9
TC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	2.6	7.7	35.9	46.2	2.6	51.4

Table J.4
School Leadership Responses for Ortiz High School (n=8)

ITEM	%Strongly Disagree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SLB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	16.7	66.7	0.0	16.7	0.0	83.3
SLB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	16.7	16.7	16.7	33.3	16.7	50.0
SLB 1.3-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	16.7	83.3	0.0	0.0	0.0	100.0
SLB 1.4- Learning should be an orderly process, where students are presented material in a sequence to be remembered.	0.0	33.3	33.3	33.3	0.0	33.3
SLB 1.5- The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	0.0	50.0	33.3	0.0	0.0	60.0
SLB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	0.0	0.0	16.7	33.3	50.0	83.3
SLB 1.7-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	16.7	33.3	33.3	0.0	16.7	50.0

SLB 1.8-Students should build their knowledge upon things they have learned in the past.	**0.0**	**0.0**	**33.3**	**66.7**	**0.0**	**66.7**
SLV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SLV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**33.3**	**66.7**	**100.0**
SLV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**0.0**	**16.7**	**33.3**	**50.0**	**83.3**
SLV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**0.0**	**50.0**	**50.0**	**100.0**
SLV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**0.0**	**50.0**	**50.0**	**100.0**
SLV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**0.0**	**0.0**	**33.3**	**66.7**	**100.0**
SLP 1.1- Math teachers work together to develop lessons.	**0.0**	**16.7**	**16.7**	**66.7**	**0.0**	**66.7**
SLP 1.2- Science teachers work together to develop lessons.	**0.0**	**0.0**	**33.3**	**66.7**	**0.0**	**66.7**
SLC 1.1- My school has identified challenges to our science, math, engineering and technology program.	**0.0**	**0.0**	**16.7**	**83.3**	**0.0**	**83.3**
SLC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**33.3**	**66.7**	**0.0**	**66.7**
SLC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	**0.0**	**50.0**	**33.3**	**16.7**	**0.0**	**16.7**
SLC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	**0.0**	**16.7**	**16.7**	**66.7**	**0.0**	**66.7**
SLC 1.5- My school made positive changes to effectively address challenges in our	**0.0**	**16.7**	**16.7**	**50.0**	**0.0**	**60.0**

science, math, engineering and technology program.						
SLC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	**0.0**	**16.7**	**16.7**	**66.7**	**0.0**	**66.7**

APPENDIX K: STEM-CAT RESPONSE SUMMARY FOR MARTINEZ HIGH SCHOOL

Table K.1

Parent Responses for Martinez High School (n=28)

ITEM	%Strongly Disgree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
PB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**3.8**	**50.0**	**11.5**	**34.6**	**0.0**	**53.8**
PB 1.2-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**3.8**	**11.5**	**0.0**	**42.3**	**42.3**	**84.6**
PB 1.3-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**3.8**	**0.0**	**3.8**	**53.8**	**38.5**	**92.3**
PB 1.4- Students should be exposed to STEM careers during the school day.	**0.0**	**3.8**	**7.7**	**50.0**	**38.5**	**88.5**
PB 1.5- During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	**0.0**	**3.8**	**0.0**	**65.4**	**30.8**	**96.2**
PB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	**3.8**	**0.0**	**3.8**	**53.8**	**38.5**	**92.3**
PV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
PV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**38.5**	**57.7**	**100.0**
PV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**3.8**	**11.5**	**46.2**	**38.5**	**84.6**
PV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**3.8**	**50.0**	**46.2**	**96.2**
PV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**7.7**	**7.7**	**34.6**	**50.0**	**84.6**

PV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**7.7**	**7.7**	**61.5**	**23.1**	**84.6**
PR 1.1- Teachers in my school have access to sufficient resources to complete activities/labs.	**3.8**	**19.2**	**46.2**	**30.8**	**0.0**	**30.8**
PR 1.2- Students in my school have access to everyday materials such as pens, pencils and calculators.	**0.0**	**7.7**	**23.1**	**46.2**	**23.1**	**69.2**
PR 1.3- There is sufficient access to technology in classrooms for curricular purposes.	**3.8**	**26.9**	**30.8**	**34.6**	**3.8**	**38.5**

Table K.2
Student Responses for Martinez High School (n=55)

ITEM	**%Strongly Disagree**	**% Disagree**	**%Neutral**	**%Agree**	**%Strongly Agree**	**% Positive Response**
SB 1.1- There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**3.2**	**45.2**	**22.6**	**25.8**	**3.2**	**48.4**
SB 1.2- In the past, I have avoided signing up for a difficult STEM course because my peers told me not to.	**25.8**	**38.7**	**12.9**	**22.6**	**0.0**	**64.5**
SB 1.3- 4. In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**0.0**	**0.0**	**16.1**	**45.2**	**38.7**	**83.9**
SB 1.4- My counselors encourage me to take advanced STEM courses that might be difficult for me.	**3.2**	**9.7**	**25.8**	**45.2**	**16.1**	**61.3**
SB 1.5- Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**0.0**	**0.0**	**6.5**	**58.1**	**35.5**	**93.5**

SB 1.6- Students should build their knowledge upon things they have learned in the past.	**0.0**	**0.0**	**9.7**	**54.8**	**35.5**	**90.3**
SV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SV 2.1- To accumulate knowledge about the world around us.	**6.5**	**3.2**	**19.4**	**41.9**	**51.6**	**76.3**
SV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**0.0**	**35.5**	**35.5**	**48.4**	**70.3**
SV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**25.8**	**45.2**	**48.4**	**78.4**
SV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**3.2**	**12.9**	**41.9**	**61.3**	**86.5**
SV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**6.5**	**29.0**	**54.8**	**29.0**	**70.3**
SR 1.1- Classes in my school are so big that the teacher spends a lot of time maintaining control instead of teaching	**3.2**	**22.6**	**48.4**	**32.3**	**12.9**	**21.6**
SR 1.2- I have a hard time learning in group activities/labs because the groups are too large for me to interact with the materials	**22.6**	**45.2**	**32.3**	**9.7**	**6.5**	**58.3**
SP 1.1- When my science and math teachers are teaching, they talk about how concepts connect to the real world.	**9.7**	**22.6**	**32.3**	**32.3**	**12.9**	**41.2**
SP 1.2- I struggle to understand what my teachers are teaching in science and math because I do not see how it applies to me.	**3.2**	**32.3**	**32.3**	**32.3**	**9.7**	**32.4**
SP 1.3- My science and math lessons begin with an interesting idea that gets me involved in the lessons.	**22.6**	**29.0**	**35.5**	**12.9**	**9.7**	**20.6**
SP 1.4- My math and science teachers ask me what I know about a topic	**19.4**	**29.0**	**25.8**	**29.0**	**6.5**	**32.4**

before we begin studying the topic.						
SP 1.5- My math and science teachers check with me to make sure I have a good understanding of concepts.	**12.9**	**19.4**	**32.3**	**45.2**	**3.2**	**42.9**
SP 1.6- When solving problems in math class, we solve problems related to real life scenarios.	**16.1**	**22.6**	**29.0**	**22.6**	**19.4**	**38.2**
SP 1.7- My teachers ask me to justify my answers in STEM classes.	**9.7**	**6.5**	**51.6**	**29.0**	**12.9**	**38.2**
SP 1.8- In my math and science classes, I have to explain concepts to other students.	**16.1**	**25.8**	**35.5**	**22.6**	**9.7**	**29.4**
SP 1.9- I have had to defend a product or conclusion in my STEM classes.	**9.7**	**16.1**	**48.4**	**29.0**	**6.5**	**32.4**

Table K.3
Teacher Responses for Martinez High School (n=27)

ITEM	**%Strongly Disagree**	**% Disagree**	**% Neutral**	**%Agree**	**%Strongly Agree**	**% Positive Response**
TB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	**23.1**	**46.2**	**11.5**	**15.4**	**3.8**	**69.2**
TB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	**7.7**	**15.4**	**23.1**	**46.2**	**7.7**	**53.8**
TB 1.3-Students should have opportunities to participate in extra-curricular activities related to science, mathematics, engineering or technology.	**0.0**	**0.0**	**3.8**	**57.7**	**38.5**	**96.2**
TB 1.4-In science and mathematics classrooms, students should be encouraged to challenge ideas while maintaining respect for what others have to say.	**0.0**	**0.0**	**0.0**	**53.8**	**46.2**	**100.0**
TB 1.5-Students should learn that all science is based on a single scientific method—a step-by-step procedure that begins with 'define the problem' and	**0.0**	**38.5**	**23.1**	**30.8**	**7.7**	**38.5**

ends with 'reporting the results.'						
TB 1.6-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	7.7	50.0	3.8	38.5	0.0	57.7
TB 1.7-Learning should be an orderly process, where students are presented material in a sequence to be remembered.	7.7	30.8	23.1	34.6	3.8	38.5
TB 2.1-The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	7.7	46.2	19.2	26.9	0.0	53.8
TB 2.2-Students should be exposed to STEM careers during the school day.	0.0	0.0	19.2	69.2	11.5	80.8
TB 2.3-During a lesson, students need to be given opportunities to investigate, debate and challenge ideas with their peers.	0.0	0.0	15.4	65.4	19.2	84.6
TB 2.3-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	0.0	3.8	3.8	69.2	23.1	92.3
TB 2.4-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	3.8	26.9	30.8	30.8	7.7	38.5
TB 2.5-Students should build their knowledge upon things they have learned in the past.	0.0	0.0	7.7	76.9	15.4	92.3
TV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
TV 2.1- To accumulate knowledge about the world around us.	0.0	0.0	0.0	23.1	76.9	100.0
TV 2.2-To be able to have an educated debate about policies in our community.	0.0	3.8	7.7	53.8	34.6	88.5

TV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**7.7**	**46.2**	**46.2**	**92.3**
TV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**0.0**	**38.5**	**61.5**	**100.0**
TV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**15.4**	**15.4**	**38.5**	**30.8**	**69.2**
TR 1.1- Class sizes in STEM courses are small enough to focus teaching time on instructional methods rather than classroom management	**15.4**	**26.9**	**26.9**	**23.1**	**7.7**	**30.8**
TR 1.2- STEM teachers skip labs/activities when they do not have access to the necessary materials.	**0.0**	**3.8**	**46.2**	**38.5**	**11.5**	**3.8**
TR 1.3-Students in my school have access to everyday materials such as pens, pencils and calculators.	**0.0**	**11.5**	**15.4**	**50.0**	**23.1**	**73.1**
TR 1.4-Teachers often purchase materials for activities/labs with their own money.	**0.0**	**0.0**	**7.7**	**42.3**	**50.0**	**0.0**
TR 1.5- There is sufficient access to technology in classrooms for curricular purposes.	**3.8**	**15.4**	**34.6**	**42.3**	**3.8**	**46.2**
TC 1.1- My school has identified challenges to our science, math, engineering and technology program.	**3.8**	**15.4**	**30.8**	**50.0**	**0.0**	**50.0**
TC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	**0.0**	**19.2**	**38.5**	**42.3**	**0.0**	**42.3**
TC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	**0.0**	**23.1**	**53.8**	**23.1**	**0.0**	**23.1**
TC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	**0.0**	**19.2**	**61.5**	**19.2**	**0.0**	**19.2**
TC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology	**0.0**	**23.1**	**46.2**	**30.8**	**0.0**	**30.8**

program.						
TC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	0.0	23.1	46.2	30.8	0.0	30.8

Table K.4
School Leadership Responses for Martinez High School (n=3)

ITEM	%Strongly Disagree	%Disagree	%Neutral	%Agree	%Strongly Agree	% Positive Response
SLB 1.1-There are some students who don't have the ability to learn science and mathematics, no matter how hard they try.	0.0	100.0	0.0	0.0	0.0	100.0
SLB 1.2-Learning about concepts within STEM fields is an orderly process; students learn by sequentially accumulating information about a topic over time.	0.0	33.3	0.0	66.7	0.0	66.7
SLB 1.3-During a lesson, all of the students in the class should be encouraged to use the same approach for conducting an experiment or solving a problem.	0.0	100.0	0.0	0.0	0.0	100.0
SLB 1.4- Learning should be an orderly process, where students are presented material in a sequence to be remembered.	0.0	33.3	0.0	66.7	0.0	33.3
SLB 1.5- The responsibility for students' learning belongs to the teacher, who must present the material in a clear and logical manner.	0.0	66.7	0.0	33.3	0.0	66.7
SLB 1.6-A STEM curriculum should help students develop the reasoning skills and habits of mind necessary to do science and mathematics.	0.0	0.0	0.0	100.0	0.0	100.0
SLB 1.7-Students should work independently as much as possible so they do not learn to rely on other students to do their work for them.	0.0	100.0	0.0	0.0	0.0	100.0

SLB 1.8-Students should build their knowledge upon things they have learned in the past.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLV intro- Rank the following reasons WHY students should learn about science, math, engineering and technology in high school from 1 (not important) to 5 (very important).						
SLV 2.1- To accumulate knowledge about the world around us.	**0.0**	**0.0**	**0.0**	**33.3**	**66.7**	**100.0**
SLV 2.2-To be able to have an educated debate about policies in our community.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLV 2.3- To understand how concepts are used to assist in their desired way of life.	**0.0**	**0.0**	**0.0**	**66.7**	**33.3**	**100.0**
SLV 2.4- To be able to make educated decisions about moral and ethical issues in current events.	**0.0**	**0.0**	**0.0**	**66.7**	**33.3**	**100.0**
SLV 2.5- To be able to understand the issues in current scientific research.	**0.0**	**0.0**	**0.0**	**100.0**	**0.0**	**100.0**
SLP 1.1- Math teachers work together to develop lessons.	**0.0**	**33.3**	**0.0**	**66.7**	**0.0**	**66.7**
SLP 1.2- Science teachers work together to develop lessons.	**0.0**	**33.3**	**0.0**	**66.7**	**0.0**	**66.7**
SLC 1.1- My school has identified challenges to our science, math, engineering and technology program.	**0.0**	**0.0**	**33.3**	**66.7**	**0.0**	**66.7**
SLC 1.2- When dealing with challenges, my school develops plans to take on those challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**66.7**	**33.3**	**0.0**	**33.3**
SLC 1.3- My school involves students and parents in developing our science, math, engineering and technology program.	**0.0**	**33.3**	**66.7**	**0.0**	**0.0**	**0.0**
SLC 1.4-My school has implemented our program to take on our challenges in science, math, engineering and technology.	**0.0**	**0.0**	**33.3**	**66.7**	**0.0**	**66.7**

SLC 1.5- My school made positive changes to effectively address challenges in our science, math, engineering and technology program.	**0.0**	**0.0**	**33.3**	**66.7**	**0.0**	**66.7**
SLC 1.6- After making positive changes to address challenges in our science, math, engineering and technology program, my school assesses the need for continuous improvement.	**0.0**	**0.0**	**66.7**	**33.3**	**0.0**	**33.3**

APPENDIX L: STRENGTHS AND AREAS OF IMPROVEMENT SUMMARY EXTENDED TO PARTICIPATING SCHOOLS SAMPLE

Overall Strengths:
After a review of the data collected from the STEM Culture Survey administered in November of 2014, the following areas have been identified as areas of strength for Sample High School:

- All four groups of stakeholders seem to recognize the value of STEM education and find it important to students especially for the accumulation of knowledge.
- Parents found value in understanding science to have a understanding of current scientific research, and teachers valued an understanding of STEM fields to be able to make good decisions about ethical and moral issues in current events. School leadership responded over 90% on values of STEM education as an application in real life, for moral and ethical issues and to be able to understand current research.
- Parents for your school seem to have beliefs that support strong STEM education, with a 90.2% positive response rate. Specific areas of strength from the parent's perspective are their belief that learning should be student centered and students should learn to use evidence to support their claims.
- The parent view of STEM education at your school is very positive, with a Positive Response Rate of almost 80%.
- Teacher beliefs about STEM education at this school are strong. Teachers from all four core areas were surveyed. The strongest areas seem to be the belief that students should support their claims with evidence and that students should have opportunities within the school to pursue STEM activities.

Areas of Improvement:
After a review of the data collected from the STEM Culture Survey administered in November of 2014, the following areas have been identified as possible areas of improvement for Sample High School:

- The view of teachers and parents regarding resources in STEM education is low (37% and 42% positive response rate respectively), specifically focused on materials within the school building available for use in STEM activities and laboratory experiments.
- Students indicate that they believe class sizes are so large that the teacher spends more time controlling the class rather than focusing on material. It is important to note that this could be a class size issue or it could also be an opportunity for professional development on classroom management of larger classes.
- Students only reported a 61% Positive Response Rate for teaching practice, specifically citing relevance of classroom material to the real world and use of student interest to engage learners.

- School Leadership reported a Positive Response Rate of 65% for beliefs, identifying that the leadership of this school (including counselors and administrators) seem to believe that STEM classrooms should be teacher centered rather than student centered, with a teacher being the disseminator of knowledge rather than a facilitator of learning. Teacher beliefs also seemed to indicate a slight lean towards a teacher centered classroom.
- While school leadership and teachers seem to have a strong belief that all students can learn science and mathematics, 43% of students and 29% of parents reported that some students do not have the ability to learn science and mathematics regardless of how hard they try. This is the only major disparity between stakeholder groups for common items.

Recommendations:

- *A professional development activity for STEM teachers on inquiry learning, specifically focused on creating a student centered classroom. It would also be beneficial for school leadership to participate in these activities when possible. These activities will not only help teachers create an environment for student centered learning, but will also increase student engagement and help with classroom management in larger classes.*
    - *It might be beneficial for non-STEM teachers to participate in a short 2-3 hour professional development activity focused on student centered learning as well, with less of a focus on inquiry instruction.*
- *Teachers within STEM classes could spend departmental time creating connections between their content and the real world to be used within their lesson plans rather than as a blanket statement explaining how content connects to the real world. These connections could be used within the inquiry learning mentioned previously as part of an engaging activity.*
- *A professional development plan for teachers could be implemented to design activities and experiments with common everyday objects. There are many resources both on the internet and through other instructional materials that allow for strong STEM activities without spending a lot of money. A meeting with STEM teachers and a district wide grant writer could be another method of finding resources to buy some of the more costly STEM materials. Finally, inviting parents to be a part of collecting materials and accessing resources from the community might help the parent perception of STEM resources.*
- *An effort might be made on the part of the counselors and STEM teachers to find posters, videos to share and other small group activities that encourage students that all students can learn science and mathematics over time, and STEM fields are not limited to the brightest students.*

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